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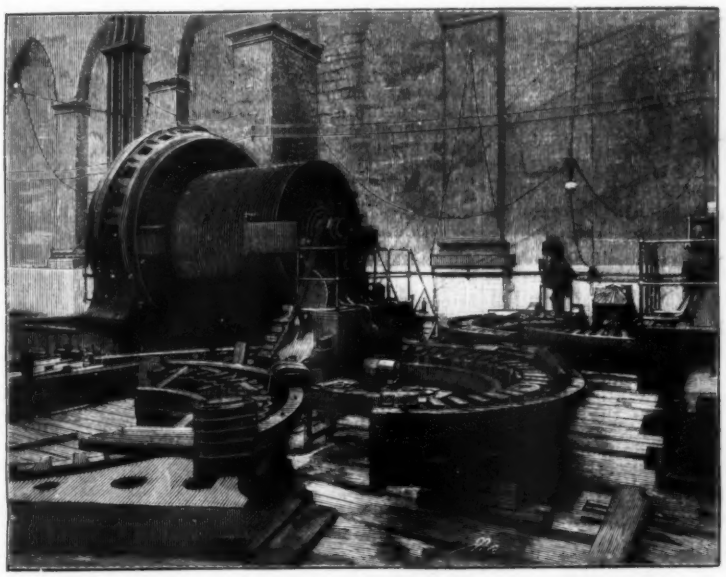
THE ELECTRIC LIGHTING OF LONDON.

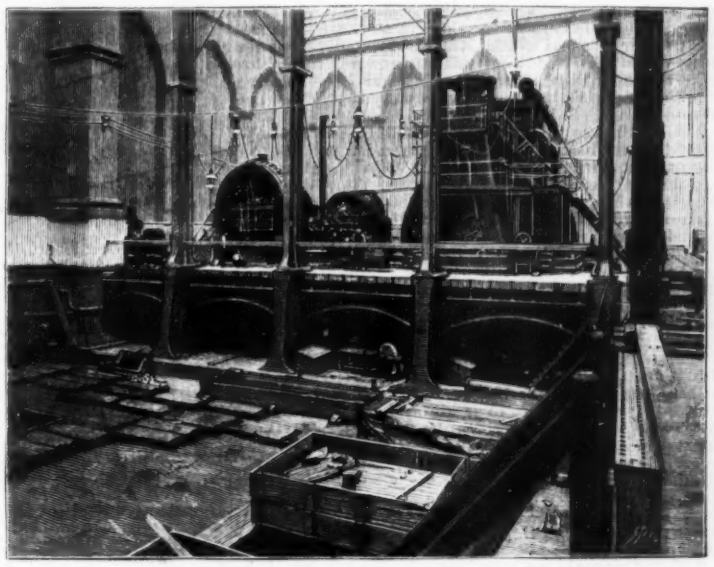
How and why, for ten or twelve years past, this great metropolis, by far the biggest collection of human dwellings, with the hugest population, and with the most immense property and income of its aggregate inhabitants that ever existed, has been outstripped by many cities of Europe and America, by foreign and colonial towns smaller than a London parish, in adopting one of the most useful and beautiful gifts of modern science for public and private use—all that is a topic of municipal history which need not here be discussed. London is soon to have the full benefit of the electric light, of which, in the principal streets of the city, on the Thames embankment, and on the bridges, we were allowed only a twelvemonth's experimental enjoyment at the cost of financial difficulties to the original companies; but some provisions of a recent act of Parliament have removed the business obstacles to the electric lighting of London. Several great companies have been formed with a capital of three millions sterling already invested in their different undertakings, which do not compete with each other, being divided, by legislative and administrative regulations, between separate metropolitan districts.

The "London Electric Supply Corporation," of which the directors are the Earl of Crawford, chairman, Sir Coutts Lindsay, Bart., the Hon. Reginald Brougham, Lord Wantage, Mr. Francis Ince, Mr. Joseph Pike, and Mr. Arthur Wade, has its head office in Adelphi terrace, and its great factory at Deptford: the last mentioned establishment in charge of Mr. Ferranti, the chief engineer, who is author of some remarkable inventions and improvements in the machinery to produce the electric light and in the means of distributing it where it is wanted.

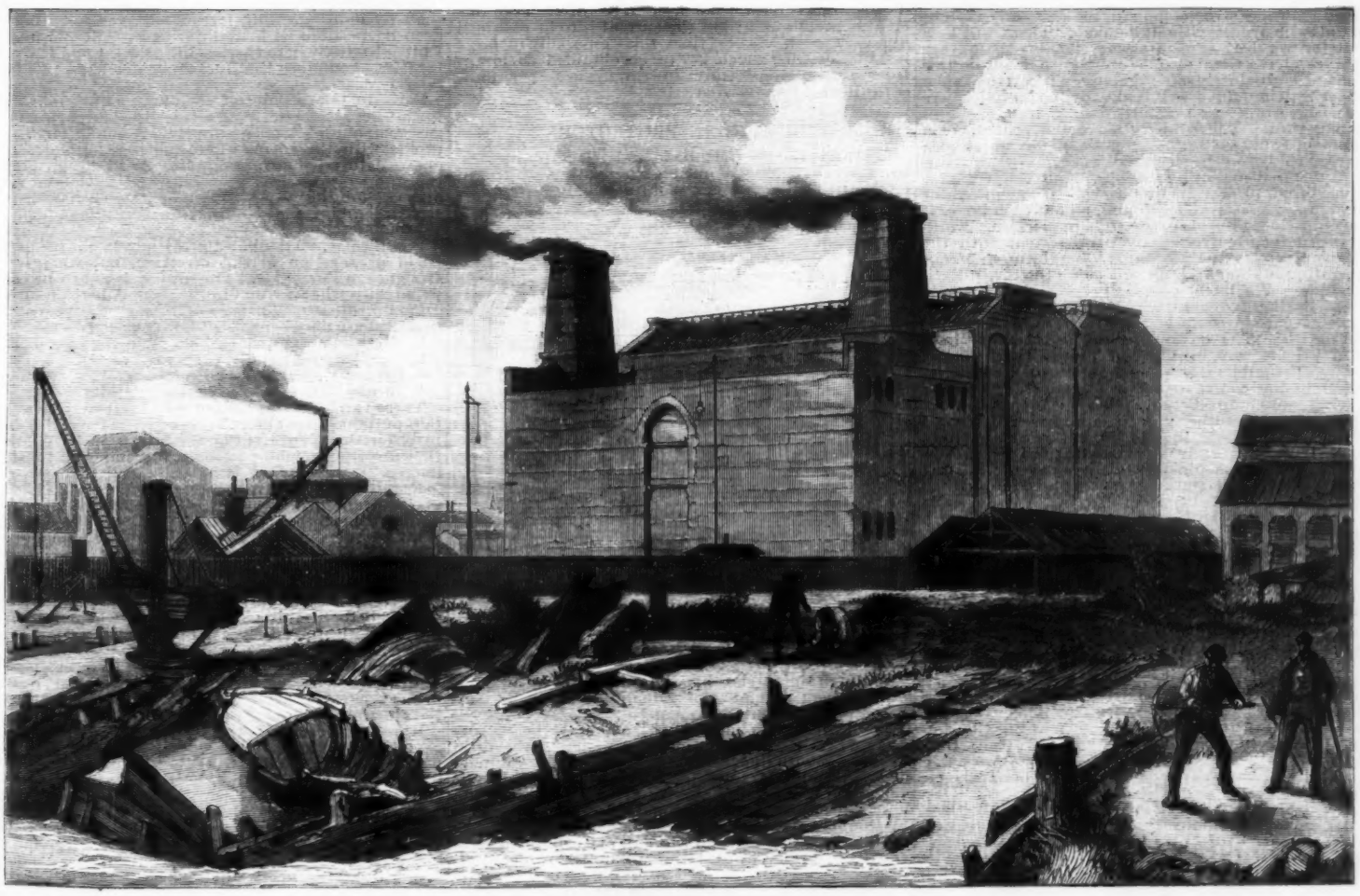
We may state, in rough outline, the extent of the metropolitan region over which this company is laying its mains—in other words, the districts apportioned to



A FERRANTI DYNAMO.



ENGINES AND DYNAMOS.



THE LONDON ELECTRIC SUPPLY CORPORATION'S WORKS AT DEPTFORD.

THE ELECTRIC LIGHTING OF LONDON.

it by the Board of Trade. The part of St. Martin's-in-the Fields lying to the south of the Strand and west of St. Martin's lane; the portion of St. Margaret and St. John, Westminster, lying to the north of Victoria street, excepting that portion of St. Margaret's lying to the west of St. George's, Hanover square; St. James, Westminster; St. George, Hanover square; Chelsea; the Greenwich district; St. Mary, Rotherhithe; St. Mary, Bermondsey; the district of St. Olave; the district of St. Saviour, Christchurch; and that portion of St. Mary, Lambeth, lying to the north of Westminster Bridge road. It is believed that this large tract of London will in the course of half a dozen years, if not less, use up the two million lamp power of the Deptford works.

This company began practically through Sir Coutts Lindsay undertaking, in November, 1884, to light the Grosvenor gallery with electricity. He received offers from neighbors to supply them with the light, and the work was made much larger than was originally intended. The demand kept on increasing till, in October, 1887, it was found necessary to move. The promoters extended their company and adopted the name of "The London."

The construction of the great works at Deptford, with their powerful machinery, was begun in April, 1888. The chairman of the company says: "We have been at it night and day ever since. Now we have a very large engine house erected, and have engines and dynamos at work of 3,000 horse power. Two other dynamos and engines are in course of construction of 5,000 horse power each. The boiler power we have put down is 14,000 horse power. We found, when we inquired as to the construction of these dynamos, that there were no tools big enough to deal with them, except a few in arsenals and private works. We tried Krupp, in Germany, and the Creusot works, in France, and neither of them would contract to deliver under three years. As it did not suit our purpose to wait so long, we put up machinery ourselves, and we shall be able to complete these dynamos in a year. They are of unprecedented size.

"The lathe required to turn the main shaft is of the same dimensions as that used for turning the 100 ton gun at Woolwich. The shafts are 36 in. in diameter, and in the rough weighed 70 tons. They were the largest castings of steel ever made in Scotland. The dynamos are 42 ft. in diameter at the armature. As to their lighting power, the dynamos working now at Deptford will supply 25,000 lights, and the two being constructed will rise to 100,000 each. These new ones are devised so that, as the demand arises, we can put another engine upon each dynamo of 5,000 horse power, so that each will be up to 10,000 horse power, making them 200,000 lights each nominally. We are also manufacturing the mains ourselves, and four machines are turning them out in 20 ft. lengths. This is all that we require for 100,000 lights. The largest of our mains will be 2¼ in. over all and the smallest 1¼ in. There is no cable, but a tube of copper, having a quarter of an inch sectional area, through which the current is sent out. This has a cover of insulating material, and a second copper tube is compressed round that for the return current. Another thin layer of insulating material is used, and over all is placed an iron tube, also made tight for protection against pick-axes in the street.

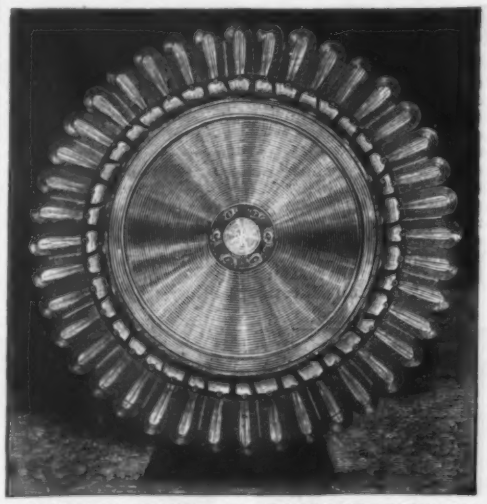
"With this main we require no box or brickwork in the streets, as it is put naked into the earth. The outer tube is wrought iron a quarter of an inch thick, and is sufficiently flexible to bend at right angles without breaking, while strong enough to resist any weight that may go over it without damage. There will be a joint for 'service' at each twenty feet, so that every house can have the light if required. A main on this principle is absolutely safe: a man can touch the naked copper with impunity, as it is already 'to earth.' There is the same protection against danger from the connecting wires. The primary current is sent up at a tension of 10,000 volts. That pressure has never been approached before in electrical work. We bring up our mains to distributing stations, where the tension is reduced from 10,000 volts to 2,400 volts. Then it is sent through the streets underground, and at each house it is again reduced by means of transformers to a working pressure of 100 volts. By arrangement with the railway company the current is brought up from our generating station at Deptford along the South-Eastern Line. We have running powers into Cannon Street Station, over Ludgate Railway Bridge, and over Charing Cross Bridge. Two mains are laid alongside the line. The advantage of this is that we have got a private way, in addition to the right of way through the public streets under our order, which we intend in due course to make use of. We have also running powers over the District Underground for these mains. Eventually we shall have eight or ten stations to distribute the light from, and at the present we have practically six, including the Grosvenor, from which the machinery will be removed later on. These distributing stations need not be larger than a good-sized room."

The "Metropolitan Electric Supply Company," with its six stations—in Sardinia Street, Rathbone Place, Whitehall, Manchester Square, Waterloo Wharf, and Greenmore Wharf—represents a capital of half a million. Its six stations will supply 300,000 lights. Here is the region of London which it is annexing: St. Giles-in-the-fields; St. George, Bloomsbury; St. Andrew, Holborn above Bars; St. George the Martyr, St. Sepulchre, Saffron Hill; Hatton Garden, Ely Rents, and Ely Place; the Liberty of Glasshouse Yard; St. Anne, Soho; St. Paul, Covent Garden; St. John the Baptist; Savoy or precinct of Savoy; St. Mary-le-Strand; St. Clement Danes and the Liberty of the Rolls; together with the extra-parochial places known as the Charterhouse, Gray's Inn, Lincoln's Inn, and Furnival's Inn; St. Martin's-in-the-Fields, except that portion lying west of St. Martin's Lane and north of Trafalgar Square.

Next comes the "Chelsea Electrical Supply Company." The "Westminster Electric Supply Corporation" extends to St. George's, Hanover Square, and parts of St. Margaret's and John's, Westminster. The "St. James' Company" provides for the Pall Mall quarter. "The House to House Electric Supply Company" is annexing portions of Kensington; "The Notting Hill Electric Lighting Company," parts of Kensington as well as of Notting Hill; while the Pilsen Company supplies Holborn and a section of the Strand.

Great as these enterprises are, they are only the beginning. The "Metropolitan," for instance, will go on building new stations as the supply of the old is taken up by householders and local authorities.

With regard to the cost and price of electric lighting, it is regulated by act of Parliament. The "Board of Trade Unit" is the quantity of electricity consumed by a ten candle power lamp in thirty hours. For this amount an electric company may charge eightpence—it must not charge more. The expression—soon to become quite common—"eightpence per Board of Trade Unit" means, therefore, one lamp of ten candle power at about a farthing an hour. Or, again, one ten candle power lamp for thirty hours means the same thing as thirty lamps, each of ten candle power, lighted, altogether, for one hour. The glow lamps should be distributed over one's house in the most advantageous positions, and they should be "switched" off when not required.

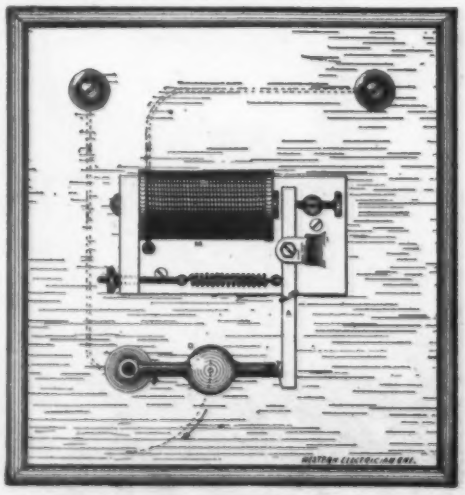


ARMATURE WHEEL OF FERRANTI DYNAMO, SHOWING ARRANGEMENT OF COILS.

People keep their gas burning all over their dwellings because they cannot be "bothered" to turn it off and on; and the trouble of lighting and extinguishing gas is considerable even in houses and business places of moderate size. It is not counted in the nominal cost of gas, but all the same it is part of the real price. The only labor required to turn on your electric light when you want it, and off when you do not, is to turn round a little brass knob. When in use, there can be no doubt that, lighting power for lighting power, electricity is as cheap as gas. It is generally supposed that the expense of installing electric light is very great; but, as a matter of fact, in new houses it is less expensive to fit than gas, and in old houses so much can be converted (meaning gas fittings) that an installation ought to be done in the very best style at from thirty-five shillings to two pounds per light. The cost of the current which is supplied by the various companies has been fixed by the Board of Trade at eightpence per unit; but the current is to be obtained at a very much less cost than this—especially in large installations, for which it can be obtained as low as from sixpence-halfpenny to sevenpence per unit. —*Illustrated London News.*

TELEPHONE PROTECTOR.

ACCIDENTS to the telephone and telegraph apparatus, from the contact of outside wires with electric light or electric railway wires, are of frequent occurrence.



Through the careless handling of a wire by an ignorant lineman, a number of valuable instruments may be destroyed or seriously damaged.

To prevent this mischievous action of heavy currents, Forest Bain, of Chicago, has designed the little device herewith illustrated. It consists of a one pole electro-magnet, M, so wound as to be energized by a current of a volume that would be liable to injure the apparatus; an armature, A, and a drop lever, D, with platinum contact at T. The magnet, armature, and drop lever, when set as in the cut, are connected electrically in a series whose terminals are the two binding posts.

This device is cut into the main line before it reaches the instruments. Its action is quite simple: Suppose a heavy current passes through the line. The armature, A, is instantly attracted, and the drop lever, D, falls, thus breaking the circuit.—*Western Electrician.*

ELECTRIC LIGHTING.

Report of M. HIPPOLYTE-FONTAINE, Engineer and Administrator of the Gramme Magneto-Electric Machine Company.

ELECTRIC lighting, in its various modes of production and employment, would necessarily occupy a prominent place in the programme of the new congress, for there are in existence few electrical industries so important from the triple point of view of the capital engaged, the variety of systems in action, and the number of applications realized.

In fact, from the last documents submitted to our consideration, it seems that at the present day there is a motive power of nearly a million H. P. converted into electric light, corresponding to a total intensity of about 200 millions of normal candles; that the number of central stations exceeds 1,500, and that of private installations 10,000; and, lastly, that the capital sunk in electric lighting amounts already to more than a thousand million of francs. The most characteristic fact that we can mention after this prodigious development is that the United States alone possess as many electric lights as all the rest of the world.

The first practical and permanent installations were made in France during the winter of 1874–75, in several workshops in Paris, and in some provincial factories, by means of continuous current dynamos and monophote regulators.*

In 1878 the candle and the regulators in series introduced the employment of the voltaic arc into shops and public streets—then, in 1880, incandescence lamps made their appearance and gave electric lighting the *entree* into private houses and all places to which the great intensity of the arc was not suited.

A French firm exhibited in 1876 at Philadelphia some dynamos and electric regulators, the working of which was irreproachable—fixity of light, regularity of action, economy of production, facility of maintenance; nothing was wanting. There were not in existence then, either in the exhibition or in Philadelphia, or even throughout America, any other apparatus capable of giving a result comparable to this (the voltaic arc was sometimes employed for luminous projections, but never for permanent lighting). Twelve years later, in August, 1888, the official statistics of the United States showed that power amounting to 459,000 H. P. was utilized in the production of electric lighting. This proves that France was the cradle of the electric lighting industry, and that the United States are a grand country, where ideas germinate and fructify with astonishing rapidity. Electric lighting is developed quickly in a country where the want of lighting is great, where public works create less hindrances to the employment of currents of tension, and where the cost of the other systems of lighting is high.

In 1878 gas was very dear in all the large towns of the United States, and the gas companies did not possess the unheard of privileges that they enjoy in France. The need of artificial lighting was considerable; electricians, being favored by a very liberal administration, were able to establish overhead cables everywhere and use currents of very high tension. Moreover, as soon as dynamos and electric lamps had taken a sufficiently practical form, the American inventive genius and commercial instinct were able to launch out freely; installations multiplied and marvelous improvements arose as if by magic. The gas companies, finding their interests seriously compromised, modified their methods, lowered their tariffs, and endeavored to obtain an increased sale otherwise than by lighting. But, fortunately, gas was able to keep its position without injuring electricity; in the United States, where there is little coal, wood and anthracite abound, so that fuel is cheap and gas comparatively dear.

Paris, to take a point of comparison in Europe, is a town where æsthetics play a considerable part, where gas companies possess great privileges and share their profits with the town, where police regulations are opposed to all innovations, etc. We can understand that, under these conditions, it would have been very difficult for the city of Paris to have benefited by electric light installations like New York, Philadelphia, Boston, etc.

It will come, no doubt; a great movement seems to be in preparation in this direction, but what is in existence in Paris at the present day is not to be compared with what we find in the great American cities.

Classification of Burners.—The lamps at present in practical use may be divided into four classes:

1. Arc regulators with carbons facing one another.
2. Candles with parallel carbons.
3. Ordinary incandescence lamps.
4. Incandescence lamps of great intensity.

These various forms are not used exclusively for certain purposes; the choice between them depends generally on the dimensions of the spaces to be lighted; they are often combined together in important installations.

Regulators.—The voltaic arc regulators have the great advantage of producing a very intense light with a small expenditure of electrical energy. The employment of them has been greatly developed in public installations, especially in the United States, where they are used for lighting whole towns; in state factories and private workshops, where we always find competent persons to superintend them; and in the service of both the army and navy, where they are utilized with equal success in operations of attack and of defense.

It is true their mechanism is easily put out of order, but this inconvenience is now almost overcome, owing to the progress made in the study and manufacture of the apparatus.

It is urged against them that they require daily attention as regards the replacing of the carbons, which, when the apparatus is not easily accessible, is inconvenient, difficult, and sometimes dangerous. But this case is rarely met with in practice now. The greater number of regulators are fed by currents of about 70 volts at the terminals of the dynamo, and only 45 to 50 at the terminals of the lamp. The fall of potential between the two apparatus arises from a metallic resistance introduced between them. Without this resistance, which often absorbs more than 30

* We do not think that the illumination of certain lighthouses and public works can be considered, properly speaking, as lighting, or we should have dated this period fifteen years earlier, still claiming for France the priority of installations.

per cent. of the available electrical energy, the light is irregular and disagreeable and subject to frequent extinctions.

The problem of doing away with this intermediate resistance has already received several solutions more or less practicable and more or less complete, but none has as yet been adopted to any extent in public or private installations.

The great interest that this question presents from an economical point of view will certainly draw upon it the attention of the members of the congress.

The *monophote* regulators, which can only be placed singly or in derivation on the same circuit, generally give a very steady and regular light. They are employed successfully in France, England, and several other countries of Europe.

The *polyphote* regulators, arranged in series, are installed very economically, as they can be placed upon conductors of very slight section. In public services this is a considerable advantage, the price of conductors being very high as compared with the other parts of the installation. In the United States regulators of this class are employed exclusively, and as many as fifty are placed on one circuit.

Candles.—The electric candles, with which the *Avenue de l'Opera* was lighted from 1878 to 1882, have not had the commercial development that was expected from their extreme simplicity. They have for ten years kept the place which they took at the outset in the large shops; they have succeeded in obtaining a footing in some establishments of the same kind and in a considerable number of factories, but the demand for them has not kept pace with the ever-increasing demand for regulators, and still less with that for incandescence lamps.

The absence of all mechanism for keeping the distance between the points of carbon constant diminishes the cost of installation and imparts to the candle an unfailing regularity of action and a facility in its employment which enables the duties connected with the lighting to be intrusted to persons without any special knowledge. They have also the advantage of being able to be placed on chandeliers of no very great height in globes from 0·3 to 0·4 of a meter in diameter, whereas the regulators nearly all require available heights exceeding 0·75 of a meter.

Lastly, owing to their capability of being clustered together in considerable numbers on the same chandelier, they admit of a long period of lighting without requiring attention.

But, on the other hand, their brilliancy and color are susceptible of slight variations, which in certain cases affect the eyes; their intensity, which is generally from 30 to 50 carcel burners, cannot exceed 100 burners; their cost price is naturally somewhat higher than that of simple carbons; lastly, they require, with an equal amount of light, a much greater motive force than the regulators.

Ordinary Incandescence Lamps.—Incandescence lamps of from 8 to 20 candles are now in universal use. They owe their immense success to their extreme convenience as compared with all other known modes of lighting, electric arc lights, gas, oil, petroleum, etc.

To light them, and also to extinguish them, all that is necessary is to turn a simple switch. Their duration exceeds 1,000 hours when care is taken not to work them at too high a pressure. Their brilliancy is very steady and their light very pleasant.

The only objection that can be urged against them relates to their great consumption of electrical energy, but we think it is mistaken economy to reduce this consumption to any considerable extent, by raising the lamps to an excessive temperature. In fact, the principal advantage of incandescence lamps consists in their long duration, and consequently in the absence of that daily attention which we mentioned when speaking of regulators, and as lamps raised to too high a temperature do not resist the action of the current nearly so long as the others, more lamps are consumed. We lose more in the one respect than we gain in the other, and at the same time deprive the lamp of its chief advantage. The lamps which consume 4 watts per candle last easily 1,000 hours on an average, whereas those which only consume 3 watts per candle rarely last more than from 300 to 400 hours.

Incandescence Lamps of Great Intensity.—Incandescence lamps of 50, 100, 500, 1,000, and even 1,500 candles are coming into use, in direct competition with the arc regulators.

These lamps, like the other incandescence lamps, last longer and consume more electrical energy when not driven at too high a pressure; and when they are over-driven they last a shorter time and consume less. Thus in each particular case we must calculate whether we shall economize the work at the expense of the lamps, or the reverse.

In the greater number of projects submitted to our consideration, we have found it advisable to use rather more energy and lessen the consumption of the lamps.

Leaving out of consideration the advantages resulting from the absolute steadiness of the lights and the convenience of their use, which amounts to examining the question from the point of view of expense only, we arrive at the following results:

A regulator receiving an initial current of 8 amperes at 70 volts consumes 560 watts, and practically requires a mechanical energy of one H. P., the cost of which varies according to the locality and the importance of the installation. We will suppose it to be 10 centimeters per hour.

If the voltaic arc is placed 4 meters above the ground we may reckon upon an available luminous intensity of 100 carcel burners and an expenditure of about 8 centimes per hour for carbons.

The replacing of the carbons is generally performed after four or five hours of action, and together with the cleaning of the apparatus necessitates an amount of manual work the cost of which may be estimated, on an average, at 4 centimes per hour.

The total cost of one light, under these conditions, not including interest, waste, and general expenses, amounts thus to 23 centimes per hour.

An incandescence lamp of 100 carcels costs 40 francs, it lasts on an average 400 hours when the expenditure is 2½ H. P., and 1,000 hours with an expenditure of 3 H. P. The cost per hour is 35 centimes in the first case and 34 in the second.

If the cost of attendance and of the carbons rises, or if that of the motive power falls, it may happen that the incandescence light costs less than the arc light. This is what almost always happens when waterfalls are used to work the dynamos.

The necessity of replacing the carbons every day in the arc regulators is the principal cause of the inferiority of these lamps to the large incandescence lamps. It will perhaps one day lead to the latter entirely superseding regulators of small and average intensity. The manual work is in fact not only a source of expense, it is an obligation that often entails great inconvenience.

Central Works.—The working of the central stations varies according to the amount of lighting required and the nature of the currents and lights employed.

If we except the works that supply the candles in the port of Havre, we may state that until lately continuous currents were the only ones used in central stations. But during the last few years, alternating currents have come into favor, and large installations have been established in which they have been employed.

In Europe, the incandescence lamp is used almost exclusively by municipalities and for private establishments; in America, arc regulators and incandescence lamps are both used, and are often to be seen in the same installation.

Continuous Current Works.—When incandescence lamps are used, these lamps are supplied directly by the circuits of the dynamos, or indirectly by the intervention of accumulators. The direct supply is generally effected at the present day according to the following principles: The dynamos are each worked by a special motor, or arranged two upon one motor. Each of these pairs forms one complete group, and the system consists of a variable number of these groups. (The employment of a very powerful motor, working a certain number of dynamos, has the disadvantage of not working economically during the greater part of the day, owing to the variations in consumption.)

The supplies of currents to consumers are effected by a system of conductors passing through all the streets, and forming a veritable network. This system is supplied by main conductors, on which no derivation is taken, and for each of which the loss of charge, independently of the length, is the same.

The difference of potential is thus kept constant at all the points where the branch conductors are joined to the principal conductors, so that from these points uniform secondary currents flow, so to speak.

The system with three conductors, working with the grouping of the dynamos in pairs, and the union of all the dynamos at the works upon strong bars of copper, from which proceed the main conductors, also constitutes two points essential to this mode of installation. When arc regulators are used, similar arrangements can be employed, especially when the spaces to be lighted are concentrated near the dynamos; but when it is required to light a town or a vast workyard, distribution in series becomes necessary. Then distinct circuits are employed, each supplied by a special machine.

Works with Accumulators.—At first, accumulators were used as reservoirs of electricity. A certain number of batteries were introduced along the line, and constituted secondary stations. These stations comprised two batteries each: the one being charged from the system, the other, independent of the system, discharging upon the lamps. Every day these batteries are changed, the one taking the place of the other.

Subsequently the role of the accumulators was reduced to that of regulating flywheels. For this purpose they were placed in series along the line, and from the extremities of each battery, conductors proceeded, forming a local circuit, which was connected to the lamps. In this system the accumulators become charged during the periods when the consumption of light is very slight, and they discharge, adding their current to that supplied directly from the works, at the time when the consumption is at its maximum.

Lastly, in some more recent installations the accumulators are removed automatically, one by one, from the battery and introduced each in its turn for a few minutes into the line where it becomes charged, the others discharging upon the circuit of lighting. The charge is effected under a constant current by means of a dynamo worked by a steam motor, the speed of which is regulated automatically, so as always to insure the fall of potential suited to the maintenance of this current.

Alternating Current Systems.—The works using alternating currents only differ from one another by the mode of employing the dynamos and the manner in which the primary and secondary systems are constituted.

In order to make the production meet the consumption when the latter is increased, we add to the service in succession dynamos which remain inactive when the demand is not so great, or else substitute a more powerful machine for the one already working. We may also, with the same view, form the distribution into several distinct systems, connect these systems together at times when the consumption is not very great, and separate them, allotting a special machine to each when the consumption is at its maximum.

Lastly, at important stations, the machines are so constructed that it is possible and easy to connect them in derivation upon the principal outgoing cables. There is then no difficulty in suiting the production to the expenditure; the distribution is effected, as in a continuous current system, by the successive addition of complete groups.

The distribution by transformers is effected in derivation; nothing has come of the attempts made with a view to grouping in series. As it is easy to reduce the loss in the primary line as much as is required, these apparatus generally branch directly from the principal circuit; but if the number of these were considerable and the system very extensive, the same arrangements would be made as in continuous current stations.

The transformers are placed either in sheds or outside the station on supports fixed to the walls, or upon the posts that support the wires.

As to the secondary system, it is utilized in two ways: sometimes each consumer or group of consumers is supplied by a single transformer having no connection with the others; sometimes all the transformers are connected into a common system to which all the conductors of the consumers are attached.

Comparison.—The advantages and disadvantages of the various modes of working have given rise to very animated discussions, which we will briefly sum up.

Continuous currents lend themselves readily to the sale of the motive power, to electro-chemical decompositions, and seem favorable to the supply of regulators. Their defects are having a limited radius of action, owing to the expense of the conductors and losing a great quantity of energy in the system. Alternating currents, on the contrary, have a very extensive radius of action and give rise to very insignificant losses of energy; but they cannot be used for chemical decomposition, and are ill-suited for distributions of motive power.

The distributions by means of accumulators have in their favor the almost complete suppression of stoppages; but the material required is cumbersome, expensive, and not durable.

Their radius of action is more extensive than that of direct distributions with continuous currents; however, the economy in conductors resulting from it is far from compensating for the losses arising from the transformation by the accumulators and overcharges which are inevitable.

Conclusion.—In this short notice we have broadly shown the origin of electric lighting, its importance at the present day, the systems of burners in use, and the various modes of working at the central stations.

In order to complete the requirements of the programme, we ought also to have entered into the luminous intensities generally adopted in the various public and private systems of lighting. But we have found so much difference and so many contradictions in the opinions expressed by practical men on this interesting question that we think it best to leave to the congress the task of stating the problem, developing it, and, if possible, solving it.

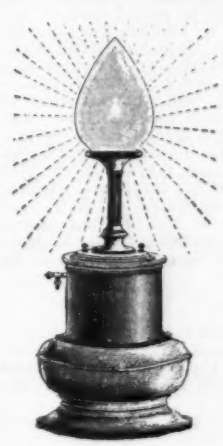


FIG. 1.

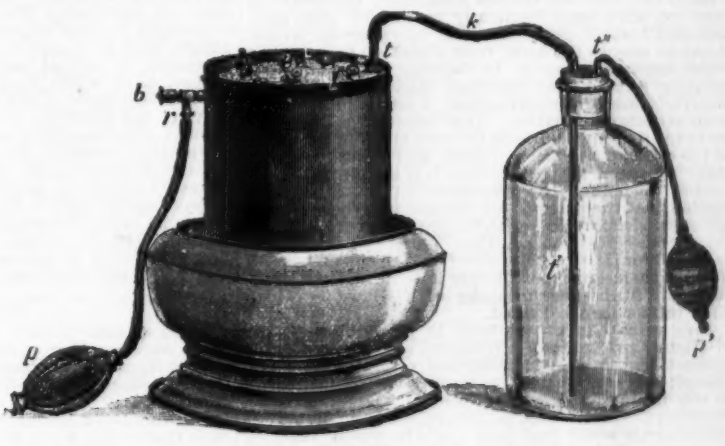


FIG. 2.

THE RENARD ELECTRIC TABLE LAMP.

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THE Renard primary battery, which was originally devised with a view of obtaining a light battery for driving the electric motors in connection with the Renard-Krebs dirigible balloon, is now being used for domestic lighting purposes, and it was recently employed to supply current to the arc and incandescent lamps lighting the rooms at the Societe d'Encouragement on the occasion of the joint meeting of the Institution of Electrical Engineers and of the Societe Internationale des Electriciens. The negative element of the Renard battery is platinized silver foil shaped into a tube, in the center of which the zinc rod is placed. The liquid is a solution of chromic acid, hydrochloric acid, and sulphuric acid, and is contained, as a rule, in glass tube-like cells. The spent liquid, it may mentioned, is a powerful disinfectant.

A 25 candle lamp, weighing 35 lb., and containing a sufficient charge for from five to eight hours, is shown in Fig. 1. The battery consists of seven Renard elements connected in series, and it is capable of giving a current of 4 amperes at 11 volts for the above-mentioned period. In order to charge the battery the candelabrum is removed, and the seven zincs are placed in their respective apertures on the vulcanite lid and screwed up; the solution is then poured into the reservoir by the remaining aperture, and the candelabrum is replaced. The liquid is driven from the reservoir into the cells by means of the India rubber ball, *p* (Fig. 2), the stopper, *b*, being previously screwed down, and

the tap, *r*, opened. When the light is no longer required the air in the reservoir is allowed to escape, and the liquid falls clear of the zincs. To empty the spent solution the candelabrum is taken off, the zincs removed, and the liquid is pumped into a glass jar by means of the aspirator *p* (Fig. 3). The composition of the liquid for one charge is as follows: Water 5¼ pints, muriatic acid 0·7 pint (400 cub. cms.), sulphuric acid 0·67 pint (380 cub. cms.), chromic acid 2 lb. 7 oz. The price of these ingredients is about two shillings, so that the cost of the candle hour may be taken at about one farthing.

This lamp, which is sold in England by Aron Brothers, of Bridewell Place, seems to possess several advantages over many of the domestic electric lamps hitherto in use. The cleansing operations are reduced to a minimum, owing to the absence of crystal deposits, and the difficulties of mounting and unmounting, which act as such formidable deterrents to the employment of primary batteries, have been largely overcome. The acids employed are, moreover, such as are easily obtainable in the ordinary way.—*The Electrician.*

THE MOLECULAR STRUCTURE OF MATTER.*

I HAVE had considerable difficulty in selecting a subject which should form the main feature of my address. This meeting being held in Newcastle, it seemed almost imperative that I should dwell upon two industries which may be said to have had their genesis here; that I should direct your attention to the extraordinary development of the system of transmitting power by hydraulic agency, and the use of the same agency for lifting enormous weights or exerting mighty pressures, and that I should not neglect to notice a manufacture of specially national importance—that of heavy artillery, and of ships of war sent forth fully equipped and ready to take their places in our first line of defense.

The desire which I felt of treating of these subjects was heightened by the opportunity which it would have afforded of paying a tribute of respect and admiration to the distinguished citizen of this town who by his genius and perseverance created the Elswick Works, raised the character of British engineering, and rendered his country services so eminent that her Majesty has seen fit to recognize them by bestowing honors higher than any which an engineer has hitherto been able to achieve.

But I felt that the themes mentioned, important as they are, have been frequently treated by able men, and that I would perhaps render more service to mechanical science if I drew your attention to a subject which appears to me to be bearing with daily augmenting force on the practical manipulation of the materials used in construction. I allude to the molecular structure of matter. This branch of science has, up to the present time, been left very much in the hands of the chemist and the physicist, and I dare say that many engineers may think that it is by no means desirable to change the arrangement; but I am persuaded that the progress of engineering, the more exact methods of dealing with the properties of materials, the increased demands on their powers of endurance, render it imperatively necessary that mechanics should interest themselves more deeply in their internal structures and in the true meaning of the laws by which their properties are defined.

Five years ago, at Montreal, in his address to the Mathematical Section, Sir William Thomson took for his subject the ultimate constitution of matter, and discussed, in a most suggestive manner, the very structure of the ultimate atoms or molecules. He passed in review the theories extant on the subject, and pointed out the progress which had been made in recent years by the labors of Clausius, of Clerk Maxwell, of Tait, and of others, among whom his own name, I may add, stands in unrivaled prominence." I will not presume to enter into the field of scientific thought and speculation traversed by Sir William Thomson, because I am only too conscious that both my mathematical knowledge and my acquaintance with the natural sciences are too limited to entitle the views which I may have formed to any respect; I propose to draw attention only to some general considerations, and to point out to what extent they practically interest the members of this section.

In a lecture delivered at the Royal Institution last May, Professor Mendeleeff attempted to show that there existed an analogy between the constitution of the stellar universe and that of matter as we know it on the surface of the earth, and that from the motions of heavenly bodies down to the minutest interatomic movements in chemical reactions the third law of Newton held good, and that the application of that law afforded a means of explaining those chemical substitutions and isomerisms which are so characteristic especially of organic chemistry. Examined from a sufficient distance, the planetary system would appear as a concrete whole, endowed with invisible internal motions, traveling to a distant goal. Taken in detail, each member of the system may be involved in movements connected with its satellities, and again each planet and satellite is instinct with motions which, there is good reason to believe, extend to the ultimate atoms, and may even exist, as Sir W. Thomson has suggested, in the atoms themselves. The total result is complete equilibrium, and, in many cases, a seeming absence of all motion, which is, in reality, the consequence of dynamic equilibrium, and not the repose of immobility or inertness. The movements of the members of the stellar universe are, many of them, visible to the eye, and their existence needs no demonstration; but the extension of the generalization just mentioned to substances lying, to all appearances, inert on the earth's surface, is not so apparent.

GASES.

In the case f gases, indeed, it is almost self-evident that they are composed of particles so minute as to be invisible, in a condition of great individual freedom. The rapid penetration of odors to great distances, the ready absorption of vapor and of other gases, and the phenomena connected with diffusion, compression, and expansion, seem to demonstrate this. One gas will rapidly penetrate another and blend evenly with it, even if the specific gravities be very different.

The particles of gases are, as compared with their own diameters, separated widely from each other; there is plenty of room for additional particles; hence any gas which would, by virtue of its molecular motion, soon diffuse itself uniformly through a vacuum will also diffuse itself through one or more other gases, and once so diffused, it will never separate again. A notable example of this is the permanence of the constitution of the atmosphere, which is a mere mixture of gases. The oxygen and the nitrogen, as determined by the examination of samples collected all over the world, maintain sensibly the same relative proportions, and even the carbonic acid, though liable to slight local accumulations, preserves, on the whole, a constant ratio, and yet the densities of these gases differ very greatly.

LIQUIDS.

Liquids, though to a much less degree than gases, are also composed of particles separated to a considerable relative distance from each other, and capable of unlimited motion where no opposing force, such as gravity, interferes; for under such circumstances their energy of motion is not sufficient to overcome the downward attractions of the earth; hence they are constrained to maintain a level surface.

The occlusion of gases without sensible comparative increase of volume shows that the component particles are widely separated. Water, for example, at the freezing point occludes above one and three-quarters times its own volume of carbonic oxide and about 480 times its volume of hydrochloric acid, with an increase of volume, in the latter case, of only one-third, and sulphuric acid absorbs as much as 600 times its bulk of methylic ether.

The quantity of gas occluded increases directly as the pressure, which seems to indicate that the particles of the occluded gas are as free in their movements among the particles of the liquid as they would be in an otherwise empty containing vessel. Liquids, therefore, are porous bodies whose constituent particles have great freedom of motion.

It is no wonder, consequently, that two dissimilar liquids placed in contact with each other should interpenetrate one another completely, if time enough be allowed; and this time, as might be expected, is considerably greater than that required for the blending of gases, because of the vastly greater mobility of the particles of the latter. The diffusion of liquids takes place not only when they are in actual contact, but even when they are separated by partitions of a porous nature, such as plaster of Paris, unglazed earthenware, vegetable or animal membranes, and colloidal substances, all of which may be perfectly water-tight in the ordinary sense of the term, but yet powerless to prevent the particles of liquids making their way through simultaneously in both directions. The rate of diffusion increases with the temperature; but an increase of temperature, we know, is synonymous with increased molecular motion of the body, and with increased activity of this kind we would naturally look for more rapid interchanges of the moving atoms. Such phenomena are only conceivable on the supposition that active molecular motion is going on in an apparently still and inert mass.

SOLIDS.

When we come to solid substances, the same phenomena appear. The volumes of solids do not differ greatly from the volumes of the liquids from which they are congealed, and the solid volumes are generally greater.

The volume of ice, for example, is one tenth greater than that of the water from which it separates. Solid cast iron just floats on liquid iron, and most metals behave in the same way; consequently, if the liquids be porous, the solids formed from them must be also; hence, as might be expected, solids also occlude gases in a remarkable manner. Platinum will take up five and a half times its own volume of hydrogen, palladium nearly 700 times, copper 60 per cent., gold 29 per cent., silver 21 per cent. of hydrogen and 75 per cent. of oxygen, iron from eight to twelve and a half times its volume of a gaseous mixture chiefly composed of carbonic oxide. Not only are gases occluded, but they are also transpired under favorable conditions of temperature and pressure, and even liquids can make their way through.

Red hot iron tubes will permit the passage of gases through their substance with great readiness. Mr. Goodman stated, during a recent discussion at the Institution of Civil Engineers, that petroleum passed through a red hot boiler plate half an inch thick, and it is well known that mercury will penetrate tin and other metals with great rapidity, completely altering their structure, their properties, and even their chemical compositions. The evidence of the mobility of the atoms or molecules of solid bodies is overwhelming. Substances when reduced to powder may, even at ordinary temperatures, be restored to the homogeneous solid condition by pressure only. Thus, Professor W. Spring, some ten years ago, produced from the powdered nitrates of potassium and sodium, under a pressure of thirteen tons to the square inch, homogeneous transparent masses of slightly greater specific gravity than the original crystals, but not otherwise to be distinguished from them.

More than that, from a mixture of copper filings and sulphur he produced, under a pressure of thirty-four tons per square inch, perfectly homogeneous cuprous sulphide, Cu_2S, the atoms of the two elements having been brought, by pressure, into so intimate a relation to each other that they were able to arrange themselves into molecules of definite proportion; and still more remarkable, the carefully dried powders of potash, saltpeter, and acetate of soda were, by pressure, caused to exchange their metallic bases and form nitrate of soda and acetate of potash.

The same movements and changes have taken place, and are still going on, in nature's laboratory. During the countless ages with which geology deals, and under the enormous pressures of superincumbent masses, stratified sedimentary rocks become crystallized and assume the appearance of rocks of igneous origin, and not only so, but rocks of whatever origin, crushed and ground to pieces by irresistible geological disturbances, reconstruct themselves into new forms by virtue of the still more irresistible and constant action of molecular forces and movements.

Those who had the privilege of hearing Professor A. Geikie's brilliant lecture at the Royal Institution last session will remember the striking series of microscopic slides which he exhibited, and by the aid of which he illustrated the changes of structure to which I have alluded. At high temperatures the same effects are more easily produced on account of the greater energy of motion of the atoms or molecules. In the process of the manufacture of steel by cementation, or in case-hardening, the mere contact of iron with solid substances rich in carbon is sufficient to permit the latter to work its way into the heart of the former, while in the formation of malleable cast iron the carbon makes its way out of the castings with equal facility—it is a complete case of diffusion of solid substances through each other; but, on account of the inferior and restricted mobility of the particles at ordinary temperatures, a higher degree of heat and longer time are needed than with liquids or gases.

Again, when, by the agency of heat, molecular motion is raised to a pitch at which incipient fluidity is obtained, the particles of two pieces brought into contact will interpenetrate or diffuse into each other, the two pieces will unite into a homogeneous whole, and we can thus grasp the full meaning of the operation known as "welding." By the ordinary coarse methods but few substances unite in this way, because the nature of the operation prevents, or at any rate hinders, the actual contact of the two substances; but when molecular motion is excited to the proper degree by a current of electricity, the faces to be joined can be brought into actual contact, the presence of foreign substances can be excluded, and many metals not hitherto considered weldable, such as tool steel, copper, and aluminum, are readily welded, as many of us witnessed at the hands of Professor Ayrton in the highly instructive lecture on electricity delivered last year at our Bath meeting.

Again, a mere superficial union of different metals takes place readily under the influence of high temperature and moderate pressure, as we see in the operations of tinning, soldering, and brazing. The surfaces of the metals must be made as clean as possible; the solder, which melts at a lower temperature than the metal to be soldered or brazed, is applied, and at a comparatively moderate temperature and under very slight pressure the particles interpenetrate each other; the two metals unite and form an alloy, by the intervention of which the two surfaces are joined. This effect is very well illustrated by the action which takes place at the surface of contact of two dissimilar liquids. If brine, for example, be placed in the lower part of a glass tube, and ordinary water, colored in some way, be carefully poured on the top, a sharp plane of demarkation will appear, but in a short time the plane of separation will become blurred, and will ultimately disappear, a local blending of the two waters will take place, and will thus present a case of fluid welding. It seems plain, therefore, that apparently inert solid masses are also built up of moving particles in dynamic equilibrium, for without such an assumption it would be hard to explain the phenomena to which I have alluded.

HEAT, LIGHT, AND ELECTRICITY.

But in addition to this evidence we can adduce the effects of other forms of energy, which we recognize under the names of radiant heat, light, and electricity. These we know to be forms of motion which can be communicated and converted from one to the other, from the invisible to the visible. The movement which we term radiant heat, acting through the instrumentality of the luminiferous ether, which is believed, on the strongest grounds, to pervade all space and all matter, is competent to augment the quantity of movement in the particles of substances, and generally to cause an enlargement of volume; and conversely, when the particles by contact or radiation part with their heat, either to surrounding objects or to space, the quantity of motion is reduced, the body contracts, and this contraction goes on down to temperatures far below those at which we have to work in practice, and consequently at all ordinary temperatures there must be abundant room for molecular motion.

Again, energy in the form of light operates changes in the surface of bodies, causing colors to fade, and giving to photography the marvelous power which it possesses; decomposing the carbonic acid of the atmosphere in the chlorophyl of green leaves, and determining chemical combinations, such as chlorine with hydrogen to form hydrochloric acid, or carbonic oxide with chlorine to form chloro-carbonic acid. It is inconceivable that these effects should be produced unless the undulations of light were competent to modify the molecular motions already existing in the solid, liquid, and gaseous bodies affected. Electricity exerts a similar influence. Generated by the molecular movements caused by chemical activity, whether directly, as in the primary battery, or indirectly, as in the dynamo, it is competent to increase the molecular movements in bodies so as to produce the effects of heat directly applied; it is capable of setting up motions of such intensity as to produce chemical changes and decompositions, to say nothing of the whole series of phenomena connected with magnetism, with induction, or the action through space and through non-conducting bodies, which, as in the case of radiant heat and light, seems to imply the existence of an interatomic ether.

CHANGES OF MOLECULAR EQUILIBRIUM.

Conversely, changes of molecular equilibrium, brought about by the action of external forces, produce corresponding changes in electrical currents: witness the effects of heat, for example, on conductivity, and the wondrous revelations of molecular change obtained by the aid of Professor Hughes' induction balance. The behavior of explosives illustrates also, and in a striking manner, the effects of disturbing molecular equilibrium. An explosive is a substance which contains in itself, in a solid or liquid form, all the elements necessary to produce a chemical change by which it is converted into the gaseous state. The application of heat, of pressure, or of impact, causes, as in Professor Spring's experiments, chemical union to take place, first at the spot where the equilibrium is disturbed by the application of external force, and afterward, with great rapidity, throughout the mass, the disturbance being propagated either by the air surrounding the particles or by the luminiferous ether, with all the rapidity of light; the chemical reaction is accelerated

* Presidential address to the Mechanical Science Section of the British Association, Newcastle, 1889. By William Anderson, M. Inst. C.E.

by the pressure which may arise, for example, if the explosive be confined in the chamber of a gun or in the bore hole of a blast. High explosives, as they are termed, are comparatively inert to ordinary ignition; but when the molecular equilibrium is suddenly disarranged throughout the mass by the detonation of a percussion fuse, combination takes place instantly throughout, and violent explosion follows. In a similar manner some gases, such as acetylene, cyanogen, and others, can be decomposed by detonation and reduced to their solid constituents. Professor Thorpe has devised a very beautiful lecture experiment, in which carbon disulphide is caused to fall asunder into carbon and sulphur by the detonation of fulminate of mercury fired by an electric spark. In these cases a reverse action takes place, but illustrates equally well the conversion of one form of energy into others, and the consequent disturbance of molecular equilibrium in the substances affected. It seems to me clear, therefore, that the time has come when the conception of dynamic equilibrium in the ultimate particles of matter in all its forms must take the place of the structural system of inert particles. I cannot conceive how the phenomena which I have enumerated can be explained on the supposition that matter is built up of motionless particles—how, for example, a stack of red and yellow bricks could ever change the order of arrangement without being completely pulled asunder and built up again, in which case an intermediate state of chaos would exist; but I can easily comprehend how a dense crowd of people may appear as a compact mass, streaming, it may be, in a definite direction, and yet how each member of that mass is endowed with limited motion, by virtue of which he may push his way through without disturbing the general appearance; how the junction of two crowds would form one whole, though, perchance, altered in character; and how even Professor Spring's experiments may be explained by the supposition that bystanders on the edge of a crowd would be forced, by external pressure, to form part of it and partake of its general movements.

DISSOCIATION.

It is a suggestive fact that the product of the atomic weight of certain groups of substances and their specific heats is a constant quantity, which, for the greater number of the elements, does not differ much from 6·5. This implies that the quantity of heat necessary to raise the temperature of the atoms of any one of the groups to any given extent is the same; hence these atoms will be endowed with the same amount of energy at any given temperature, and therefore would be competent to replace each other without disturbing the general dynamic equilibrium. When it is conceded that molecular motion prevades matter in all its forms, and that the solid passes, often insensibly, into the fluid, or even direct into the gaseous, it follows, almost of necessity, that there must be a borderland, the limits of which are determined by temperature and pressure, in which substances are constantly changing from one state to another. This is observable in fusion, but to a more marked degree in evaporation, where the particles are being incessantly launched into space as gas and return as constantly to the liquid state. Henri St. Claire Deville has investigated similar phenomena in chemical reactions; he has found that at certain temperatures and pressures substances fall asunder and combine much in the way in which evaporation takes place, and has given the name of "dissociation" to this property of matter. Professor Mendeleeff and others have extended the great French chemist's observations, and have formulated the general law that substances are capable of dissociation at all temperatures, not only in the case of chemical unions, but also in that of solutions.

If steel be looked upon as a solution of carbon and iron, then the hardening of steel is explained by the theory that dissociation has taken place at the temperature at which it is suddenly cooled, the sudden cooling fixing the molecular motion at such an amplitude or phase that it gives a characteristic structure, one of the properties of which is extreme hardness. In tempering, the gradual communication of heat causes dissociation again to take place, the molecular equilibrium is modified by the increased energy imparted to the particles, and when suddenly cooled at any point there remains again a distinct substance, composed of iron and carbon partly in various degrees of solution and partly free, and again possessing special mechanical qualities.

That steel, and probably other alloys, differ in the nature of their composition according to the way in which they are worked, both with respect to heat and mechanical pressure, has been abundantly proved by many eminent metallurgists, and especially by Sir Frederick Abel, in the extended researches which he has recently carried out, on the hardening of steel, for the Institution of Mechanical Engineers, and it would appear as a natural sequence that the properties of steel would be greatly affected by the manner in which its temperature was changed, as we indeed find that it is when these changes are produced by baths of melted metals, by oil, or by water at different temperatures. The action which takes place may be illustrated by what would happen supposing that a complicated dance, such as the lancers, were suddenly stopped in various phases of the figures. The component parts would always remain the same, but the relative distribution of the partners would vary continually, and analysis would show that at one time each gentleman was associated with a particular lady; at another, that two ladies were attached to a single gentleman, while a number of gentlemen had no partners at all; and yet, again, at another, that the movements which were once rectilinear have become circular. In each case the groups would assume a totally distinct appearance. In support of these views it may be stated that, as far as I know, no pure element is capable of being hardened or tempered, the reason being that no chemical change can take place when there is only one substance; the effect of heat or pressure, however suddenly applied, produces merely a change of form which does not appear to carry with it any corresponding alteration of mechanical properties. It may be urged, however, that it is unlikely that alloys or solutions could be affected in a manner so marked merely by small changes at comparatively low temperatures; but I would observe that "great and little" are relative terms, and we have abundant evidence of the immense effects produced by what would be called "little" causes. Sir Frederick Bramwell, in his address last year, drew attention to the importance of the "next to nothing." It is not so very long ago that any one would have been considered a dreamer for propounding a theory that the presence of the fraction of a per cent. of carbon, phosphorus, or sulphur would totally alter the character of iron; that the addition of one two-thousandth part of aluminum to molten iron would make the pasty mass as fluid as water; that the presence of the smallest impurity in copper would have a disastrous effect on its powers of conducting electricity, and that the addition of one-thousandth part of antimony would convert the best "selected" copper into the worst conceivable. I need hardly allude to the great part played in nature by microscopic organisms, and how much of the beauty of our seas and rivers is derived from substances so minute that nothing but the electric beam of Professor Tyndall is capable of revealing their presence.

THE PERIODIC LAW.

There is one more circumstance connected with my subject to which I must draw your attention, because, though its application to the mechanical properties of substances is very recent, it promises to be of great importance. I allude to the periodic law of Dr. Mendeleeff. According to that law, the elements, arranged in order of their atomic weights, exhibit an evident periodicity of properties, and as Professor Carnelley has observed, the properties of the compounds of the elements are a periodic function of the atomic weights of their constituent elements. Acting on these views, Professor Roberts-Austen has recently devoted much time and labor to testing their exactness with reference to the mechanical properties of metals. The investigation is surrounded by extraordinary difficulties, because one of the essential features of the inquiry is that the metals operated on should be absolutely pure.

For chemical researches, a few grains of a substance are all that is needed, and the requisite purity can be obtained at a moderate cost of time and labor; but when mechanical properties have to be determined considerable masses are needed, and the funds necessary for obtaining these are beyond the reach of most private individuals. I cannot help suggesting that wealthy institutions, such as many of those connected with our profession, could not employ their resources more wisely than in giving the means of following up the researches which Professor Roberts-Austen has inaugurated. In view of the difficulty of obtaining metals of sufficient purity, he selected gold as his base, because that metal can be more readily brought to a state of purity than any other, and is not liable to oxidation. In a communication to the Royal Society made last year he shows that the metals alloyed with gold which diminish its tenacity and extensibility have high atomic volumes, while those which increase these properties have either the same atomic volumes as gold or have lower ones. The inquiry has only just been commenced, but it appears to me to promise results which to the engineer will prove as important and as fruitful of progress as the great generalization of Mendeleeff has been to chemists. A law which can not only indicate the existence of unknown elements, but which can also define their properties before they are discovered, if capable of application to metallurgy, must surely yield most valuable results, and will make the compounding of alloys a scientific process instead of the lawless and haphazard operation which it is now.

STRESSES.

The practical importance of the views I have enunciated are, I think, sufficiently obvious. Every one will admit that an external force cannot be applied to a system in motion without effecting that motion; consequently matter, in whatever state, cannot be touched without changes taking place, which will be more or less permanent. The application of heat will cause a change of volume, and, at last, a change of condition; the application of external stresses will also produce a change of volume; and it is natural to infer that there must be some relation between the two, and, accordingly, Professor Carnelley has drawn attention to the fact that the most tenacious metals have high melting points, though here again there is a great want of exactness, partly on account of the difficulty of measuring high temperatures, and partly by reason of the scarcity of pure materials. Again, long continued stresses, or stresses frequently applied, may be expected to produce permanent changes of form, and so we arrive at what is termed the fatigue of substances. Stretched beyond their elastic limits, which limits I do not suppose to exist except when stresses are applied quickly, substances are permanently deformed, and the same effects follow the long application of heat. The constant recurrence of stresses, even those within the elastic limit, causes changes in the arrangement of the particles of substances which slowly alter the properties of the latter, and in this way pieces of machinery, which theoretically were abundantly strong for the work they had to perform, have failed after a more or less extended period of use. The effect is intensified if the stresses are applied suddenly, if they reach nearly to the elastic limit, and if they are imposed in two or more directions at once, for then the molecular disturbance becomes very intense, the internal equilibrium is upset, and a tendency to rupture follows. Such cases occur in artillery, in armor plates, in the parts of machinery subject to impact; and, as might be expected, the destructive effects do not always appear at once, but often after long periods of time. When considerable masses of metal have to be manipulated by forging or by pressure in a heated condition, the subsequent cooling of the mass imposes restrictions on the free movement of some, if not all, of the particles; internal stresses are developed which slowly assert themselves, and often cause unexpected failures. In the manufacture of dies for coining purposes, of chilled rollers, of shot and shell hardened in an equal manner, spontaneous fractures take place without any apparent cause, and often after long delay, the reason being that the constrained molecular motion of the inner particles gradually extends the motion of the outer ones until a solution of continuity is caused. Similar stresses occur in such masses as crank shafts, screw shafts, gun hoops, etc. The late General Kalakoutsky some seventeen years ago commenced a systematic investigation into the internal stresses in the tubes and hoops of guns and in armor-piercing shells. The method he pursued was to cut disks or rings about half an inch thick off the hoops and shells, to divide the metal of each disk into from four to six rings, to fix by means of silver plugs, on which very finely marked cross lines were drawn, from four to eight points on the surface of each ring, and then to measure, with extreme exactness, the changes in diameter produced in every ring by the successive cutting out of the rings. Knowing by direct tests the mechanical properties of his material, he was able, from the changes in the diameters, to calculate what the tangential stresses in every part of each disk were, and to draw inferences as to their fitness for the work they were intended to perform. The same method of investigation has been pursued by Captain Noble, of the Elswick Works, and by Lieutenant Crozier, of the United States Artillery, with the practical result that probably much more attention will be paid in future to the principles on which the annealing and hardening of steel is carried on. A gun hoop or tube, to be in the best condition to resist a bursting stress, should have its inner surface in a state of compression, and its outer in a state of tension, and the hoops should be shrunk on to the tubes or on to each other with but very little pressure.

(To be continued.)

WILLIAM H. CILLEY.

IT is a painful duty to chronicle the death of William H. Cilley, late general manager of the Oroya Railroad, Peru, of which he was the superintendent during construction, and who for twenty-seven years had been prominently connected with the railroad development of South America. Few men on the west coast were more widely known, and no one was more thoroughly respected or more universally esteemed.

Born in Northfield, N. H., on the 26th day of May, 1839, of a distinguished New England family, he inherited principles of rigid integrity, decision of character, firmness of purpose and reliability that shone conspicuously throughout his whole life.

He gained his first experience in railroading on one of the railroads of New Hampshire. Here he successively occupied every post from fireman, engineer, and roadmaster to chief of traffic. Endowed with a retentive memory, and giving an earnest, patient attention to detail, he made himself master of the art of railroading.

In 1862 Mr. Meiggs, having contracted to build the railroad from Quillota to Santiago, the capital of Chili (the comparatively short link from Quillota to Valparaiso being already completed), wrote to Mr. Cilley, urging him to join him in the work.

Mr. Meiggs, having finished the Valparaiso line, and extended the southern line to San Fernando, was invited by Col. Balta, president of Peru, to undertake the building of the railroad system of that republic, including the famous Arequipa and Oroya railroad, whose daring engineering is unparalleled in the history of railroad achievements. Early in the undertaking of the difficult work of the Oroya, various superintendents of construction having failed to show that skill and energy in plan and execution demanded by so exceptional a work, Mr. Cilley was summoned from a less important line in the north and given absolute control. He thus again became the lieutenant of Mr. Meiggs, who attracted to him the best engineering skill of America to aid him in the almost insuperable task of building the Andean railroads.

The location once decided upon, Mr. Cilley marshaled his little army of railroaders to the execution of the work, and the story of the result is hewn in imperishable letters of granite in the rugged defiles and on the lofty slopes of the Cordillera, where at the height of 15,600 ft. the highest tunnel in the world, nearly 4,000 ft. in length, pierces the summit.

Cilley was always on the work himself; strict in his discipline, he allowed no defective work or material to escape his scrutiny, and largely due to this strict surveillance of the operations of his subordinates is the fact that, although the line—a constant succession of curves for a length of 50 miles—has an average grade of 3½ per cent. for that entire distance, and may be, therefore, considered exceptionally liable to accident, no passenger has ever lost his life during the 18 years it has been in operation.

On the completion of the road to its present terminus he was appointed manager, and, during all the difficult and delicate situations presented by the financial crisis of 1877, followed by the disastrous war with Chili, a year or two later, his firmness, his sense of justice, and his tact saved the interests intrusted to him, when men of less integrity or courage would have been overwhelmed.

On the occasion of the terrible catastrophe of the burning of the church of the Campania in Santiago, Chili, on December 8, 1863, he was one of the devoted band of Americans who risked their lives in the effort to save some of the victims of that disaster, in which over two thousand women and children lost their lives.

In 1866, war having been declared between Spain and Chili, as the ally of Peru, the government of Chili asked Mr. Meiggs to recommend some one of ability and integrity to act as their confidential agent for the purchase of war material in the United States. Mr. Cilley was chosen for this delicate mission, and, making use of his own personal influence and credit, since the arms were only payable on delivery at destination, and the risk was great, he succeeded in buying and shipping the armament necessary, which makes the port of Valparaiso to-day almost impregnable, and prevents repetition of the sad spectacle of the bombardment of an unresisting commercial port, as witnessed by Mr. Cilley and the writer in April of that year.

His personal gifts were great. Few men could be more interesting in conversation, for he was a close student of books and of men. He impressed one as a man thoroughly acquainted with whatever subject he discussed. He was, withal, modest and self-forgetful to a degree, although his disdain of danger in any form amounted almost to recklessness. No one who has ever thundered down the grades of the Oroya on a hand car, with Mr. Cilley as his guide, can ever forget the cool audacity with which he would plunge into the depths of a yawning tunnel or whirl around the serpentine curves of that remarkable road, talking as easily and lightly the while as though riding smoothly in a palace car on one of our own perfect railroads.

His associates loved him, his employes were devoted

to him, for it can never be said that Mr. Cilley would ask a man to go where or do what he himself would be unwilling to attempt.

His whole life was one of courageous devotion to duty. Generous and self-sacrificing to those in need of him, he was the most loyal of friends, the most faithful of custodians, and was never known to neglect a trust or evade a responsibility. Nor was it among his countrymen or co-workers alone that his worth was recognized during life, or his memory honored after his death. At the funeral ceremonies in Lima, on the 12th of September, the president, represented by his aide, the secretary of the treasury, and the president of the senate, accompanied the minister, the secretary of legation, and the consul of the United States as pall bearers. Thousands of the people of Lima joined in showing their sorrow at what all felt to be a national loss. Flags drooped from their staffs in sign of mourning, a guard of cavalry represented the army, and the coffin was hidden from sight by a wealth of floral offerings, from the stately cross of the employes of the Oroya to the humble wreath of the unknown mourner his open hand had saved. And at the tomb, one of the most eloquent of the statesmen of Peru, Dr. Luciano B. Cisneros, in saying farewell to his friend of many years, paid a touching tribute to his life and character. We regret that space will not allow us to give the remarks of Dr. Cisneros in full, but must content ourselves with a few brief extracts. He said:

"Before consigning the precious remains of William H. Cilley to the obscurity of the tomb, let the friend whose hand was among the first grasped by him on reaching the hospitable shores of Peru be permitted to utter a few heartfelt words of farewell, in recognition of a sacred debt of the truest affection. . . . William H. Cilley was a worthy laborer in behalf of industry and peace. He came to Peru, not brought by the wave by which at times one is cast upon an unknown shore, to seek what the chances of destiny might give, but to lend the precious aid of his grand inspirations and of his initiative to the monumental works contracted for by Henry Meiggs. He came, therefore, bringing with him a noble profession, that inexhaustible capital, constantly renewed, which no vicissitudes of fortune can take away. He brought with him unquestioned probity and that wealth of sound liberal ideas and of severe morality inherited from his ancestors, which was the foundation of the well-deserved, honorable, and universal confidence which made his name resplendent. He brought those gifts of daring intrepidity and feverish activity which, for certain enterprises, are the distinctive characteristics of his race. In a word, he came as a pure and precious element in the building up of national progess, thus symbolizing with wonderful perfection the ideal of the foreigner beloved and cherished by Peru; of the foreigner she needs, and without whom—let it be said frankly—the regeneration of our country would be impossible, since Providence has ordained that peoples be drawn closer together and perfected through such messengers of peace, destined to bestow the benefits of their precept and example, as teachers and helpers, upon civilizations less perfect.

"Hence is it to-day, when one so worthy has left us, that the mourning people make this grief their own. . . . We cannot recall these happy relations between our lamented friend and the society around him without remembering that they were greatly strengthened by the virtues of his noble character. There is nothing grander in the sight of God, nor more consoling to the heart of man, than acts of faith and charity. Cilley never forgot this priceless maxim, and to it he owed in the varied situations of life the pure satisfaction of drying many a tear and of rescuing many a precious life from hopeless misery. . . . The pilgrimage of Cilley through this world has, therefore, not been a barren one. He was not a great genius, meriting an epic, nor was he one of those innovators who transform the fate of nations or of men; he was far from being one of those men of profound talent who draw wonderful revelations from professional experiment or from the depths of science, but to us he was useful, and the useful man commands the respect of his fellows; he was a worker who practiced morality and virtue, and it is our duty to exalt these virtues, without which national prosperity is impossible."—*C. S. R., in Railroad Gazette.*

[Continued from SUPPLEMENT, No. 723, page 11550.]

THE CHANNEL BRIDGE—PRELIMINARY DESIGNS.*

By Messrs. SCHNEIDER & Co., Creusot Iron Works, and H. HERSENT.

PART II.—CONTINUED.

Section 3. Materials and Machinery Required for the Completion of the Works.—The usefulness of a special port for the construction of the caisson, the fitting of the girders, and the sailing and floating stock has been sufficiently dealt with. Such ports, as before stated, would have to be situated as near as possible to the point at which the works are begun upon either coast. Each of these ports would have to answer the immediate and special requirements of the work, and have docks or basins enabling four caissons to be formed at the same time, and two more caissons loaded. Each will also contain buildings for storing up the iron and the cement, and the workrooms for the manufacture of the metal fittings. In fact, it will amount to an extensive works, that will supply all that is necessary for the construction of the bridge. The port will also have to be provided with suitable shunting arrangements, as well as with all that is necessary to keep the floating stock in good repair, which stock will have to be rather considerable to assist in the erection of the masonry in the offing. Nothing less than the number of vessels enumerated in the following list will be sufficient: Five steamboats of 250 horse power, carrying ballast and various compressed air engines, with the proper fitting. Ten steamboats of 300 horse power and 10 000 tons capacity for conveying the working material to the spot. Each one of these vessels will be divided so as to be able to hold convenient proportions of the different categories of materials that are to be employed, and will also be fitted with the necessary machinery for loading and unloading, for manufacture of mortar, and production of electric light. Twenty-five anchoring barges for mooring, provided each with a machine and a winch for mooring and lifting the anchors. Five tugs or lighters for keeping the various materials in reach of the works in the offing. Two barges with masts, yards, etc., for putting up and taking down the domes, of from fifty to sixty tons each. Thirty unsinkable barges for the port traffic and for the conveyance of accessories. The gangways will be arranged in such a manner as to receive the goods as they come from the interior of the country from the railway station direct. The quays will be provided with cranes of various degrees of power, corresponding to the weight of the pieces they have to lift.

Section 4. Cubing, Estimates, and the Time Required for Completion of Works.—The following table shows in a condensed form the importance and the number of the piers to be constructed, such construction requiring about four million cubic meters of masonry and about seventy-six thousand tons of metal.

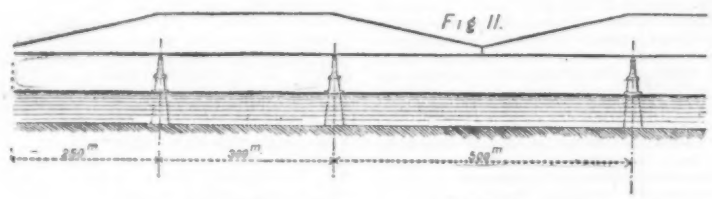
Table of the Work to be Performed for the Construction of the Piers.

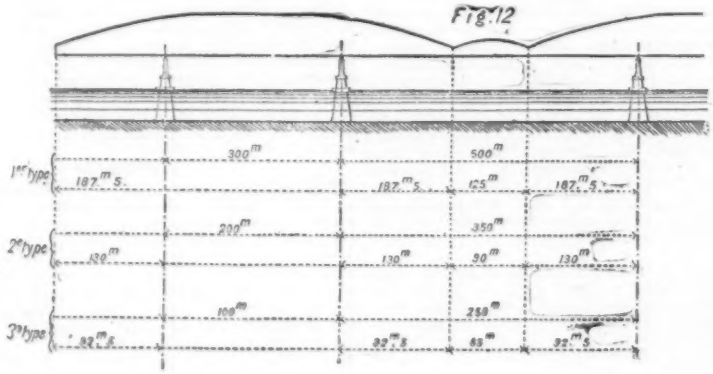
Piers under Low Water.	Masonry.			Caissons.		Remarks.
	Breadth of Piers.	Cubic Meters per Pier.	Total in Cubic Meters.	Weight of Caisson.	Total Weight.	
Meters.						
5	14	17,300	242,200	311,000	4,354,000	
10	6	20,500	123,000	386,300	2,317,800	
15	8	24,500	196,000	466,800	3,734,400	
20	18	28,600	504,000	561,600	10,108,800	
25	30	31,900	957,000	618,600	18,558,000	
30	16	37,600	601,600	697,000	11,152,000	
35	2	40,500	81,000	790,300	1,580,600	
40	6	45,400	260,400	873,800	5,242,800	
45	4	48,000	192,000	966,400	3,865,600	
50	4	52,600	210,400	1,058,300	4,232,800	
55	10	57,200	572,000	1,163,300	11,163,300	
	118		3,939,600		76,309,800	

If it be desired to complete the whole of the works within a period of ten years, which does not seem at all impossible, about two years would have to be devoted to preparatory works for establishing working yards and buildings, so that the whole time, with this preparatory period included, would extend over twelve years. In such a case the foundation work would have to be completed one year before the superstructure is begun, but it might be commenced even a little before the first year has quite elapsed. Thus ten years may be considered as necessary for the foundation works and the superstructure. The labor would have to be divided between two working yards situated on either coast, so that each yard would have to turn out two million cubic meters of masonry, concrete, and caissons, to the amount of 40,000 tons each in a year, with the amount of 200,000 cubic meters of masonry and 4,000 tons of iron caissons. The iron would be supplied from existing works, so that no difficulty would be encountered in this respect, except that to the annual 4,000 tons will have to be added the iron necessary for the superstructure. The plant required, however, for this demand exists, and this is the main point. As regards the masonry, there are some difficulties that would have to be contended with, not on account of the quantity of 200,000 cubic meters that must be turned out every year, but owing to drawbacks inherent to any work to be performed in the sea, as well as to the inconvenience attending the conveyance of men to the spot and the loading and unloading of materials. In the maritime works performed in the port of Antwerp, 600 cubic meters of brickwork or of concrete have been turned out every day, and in the construction of docks at Misiessy, 200 cubic meters of masonry for each caisson were easily supplied. At Boulogne and Calais the condition of the sea enables work to be carried on by dredging machines from 200 to 250 days per year, which goes to show that if in the Channel bridge a better adapted and stronger material be used, the works can be carried on from 40 to 50 days longer, *i. e.*, from 250 to 300 days a year, or, on an average, for 275 days per annum. Deducting the holidays, however, the work will not be continued for more than 250 days, so that it will be necessary to turn out each day $\frac{200,000}{250} = 800$ cubic meters of masonry. It does not appear to be possible to put more than 100 cubic meters of masonry per diem into one pier caisson, so that to obtain the total quantity of work required it would be necessary to operate on eight caissons at once, and, besides, perform the preparatory and supplemental operations separately. In estimating the time that would probably be required to perform each of these operations, one can at once form an idea of the number of columns that will have to be operated upon at the same time.

Average Column with Base at 30 M. below the Low Water Level.	Quantities.	Time.	Remarks.
		Days.	
Construction of caissons	607,000 k.	60	
Loading same before moving	2,300 m.³	10	
Conveying same to place of sinking		2	
Masonry to be erected before sinking	17,500 m.³	175	
Clearing the ground (?) under the edge		30	
Fitting in place and final clearing of ground		20	
Application of concrete	2,400 m.³	20	
Time lost through bad weather and holidays		100	
		417	

The supply of the immense quantity of necessary material does not appear to offer any very great difficulties. As regards the concrete and the rough bricks and stones, the chalk quarries situated near Marquise may easily be taken advantage of, and they will probably suffice to supply all that is necessary in this respect with the assistance of a railway line. The shipping of such materials may be divided among the ports of Calais, Boulogne, and Ambleteuse, proportionately to the facilities which each of those ports offers. The unloading on the spot where the work is carried on will be effected by laborers, assisted by special machinery, and no complications are to be feared in this connection except such as may arise from the unsatisfactory condition of the sea, which may be guarded against in the manner indicated in the preceding chapter. The sand required for making the mortar will be supplied by the beach. Cement is manufactured in considerable quantities all around Boulogne, from whence 50,000 tons per annum can be easily obtained. The granite for the capping of the piers may be derived from the quarries of Chausey, Flamanville,





etc., situated on the coast, and placed beforehand in a condition suitable for the purpose.

PART III.—SUPERSTRUCTURE—PRELIMINARY PROJECT OF MESSRS. SCHNEIDER & CO.

V.—CHOICE OF SYSTEMS OF GIRDERS.

The idea of placing non-continuous girders upon piers erected at regular intervals of 500 m. must be rejected at once. It is true that this system would offer the unquestionable advantage of considerably reducing the number of piers that might constitute obstruction to the navigation; but it would, on the other hand, be attended by the drawback of increasing the weight of the bridge extremely, for it is well known that the weight of a girder with two points of support increases much more rapidly in proportion to the span than a girder arranged in cantilever system. It would seem advisable to form large cantilever spans, but such an arrangement requires that between the points of support of the same girder a sufficient length is left for insuring the stability of the work during construction, and to make up for the varying distribution of the overcharge, as well as to meet the emergency of excessive gusts of wind. It will be understood that, from the standpoint of economy, it would be desirable to reduce this length as much as possible—100 m. for instance, would be a satisfactory length; but then it may be objected that, in many cases, these lengths of 100 m. would interfere with navigation, especially with that of sailing vessels. It would, therefore, be necessary, to avoid multiplying such obstacles, to increase the distance between the piers. This distance has consequently been fixed at 300 m. at the deepest part of the sea, where the spans, arranged so as to form cantilevers, would, therefore, attain 500 m. It has been stated before that, in addition to the alternate spans of 300 m. and of 500 m., there would also be spans of 200 m. and 350 m., and another set of spans of 100 m. and 250 m. respectively, to be placed at the points corresponding to the elevated portions of the ground, and in the vicinity of the coasts.

In considering the spans of 300 m. and 500 m., the first idea that occurs is to form the spans of girders extending over the whole length of 300 m., and extending on either side in the form of cantilevers of 250 m.,

* A paper read at the meeting of the Iron and Steel Institute, Paris, 1889.—*From the Engineer.*

so that the junction of two cantilevers should constitute a span of 500 m. in all.

Fig. 11 shows this arrangement. It is a well-known fact that in the Forth bridge the two large spans are not completely covered by the cantilevers, the latter being connected by an ordinary independent span. It therefore becomes necessary to ascertain whether the addition of such an independent span would result in diminishing the weight.

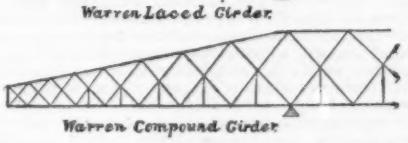
The nature of this paper does not enable us to reproduce the calculations to which this inquiry has conducted us, but it may be stated that these calculations have shown that the addition of an independent span is advisable, and that, supposing the distance between the points of support to be 500 m., the space comprised between one-third and one-fourth of the distance between the points of support is the best indication of the length to be given to the same, for by this means a saving of about 17 per cent. is realized on each overhanging portion of the cantilever.

The sketch, Fig. 12, shows the arrangements adopted for the three types of spans. It now remains to determine what arrangement is to be adopted with regard to the main girders of the bridge. The best girder will be the one that will necessitate the employment of least weight while offering sufficient resistance to vertical loads and presenting the least surface to the action of the wind.

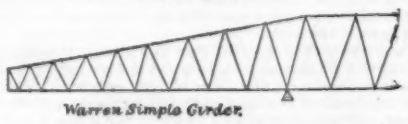
Many types of girders of the same height—Fig. 13—and presenting about the same intervals between the lower apices, have been examined, it being desirable to avoid taking into consideration the weight of the beams and of the sleepers under the rails.

FIGS. 13.

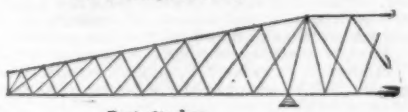
Warren Laced Girder.



Warren Compound Girder.



Warren Simple Girder.



Post Girder.

Pratt Girder.

The following table shows the weight of the different girders as compared with the weight of the Warren's compound girder:

	Warren's laced.	Warren's compound.	Warren's simple.	Post.	Pratt.
Weight to resist vertical strain	1·000	0·957	1·063	0·926	1·190
Weight to resist wind...	1·000	1·157	1·241	1·320	1·080
Proportional average....	1·000	1·047	1·143	1·123	1·141

The proportional average has been calculated on the assumption that the weight necessary to resist the wind represented $\frac{3}{11}$ of the weight sufficient to withstand vertical strain. The question has been carefully inquired into, and the present report is the result.

It will be seen that the Warren compound girder offers more advantages, and, therefore, this type of girder has been selected. The same girder has also been adopted for the independent spans connecting the consecutive cantilevers.

VI.—ARRANGEMENT OF METALLIC SUPERSTRUCTURE.*

Section 1. *Spans of* 300 *and* 500 *meters.*—It is proposed to provide the bridge with two lines of way situated at 1·50 m. apart. The upper level of the rails will be 73 m. above the low-water level, the lowermost portion of the bridge being 0·10 m. above the low-water level throughout the extent of the spans of 300 m.; while in the center of the spans of 500 m., that portion is 66·50 m. above the low-water level—see sheets 6, 7, 8, and 9.

Central Spans and Cantilever Arms.—The metal flooring of the bridge is formed of two girders resting upon two piers 300 m. apart, and lengthened on either side to the extent of 187 m., the arms of the cantilevers being 500 m. apart.

These girders are 11 m. high at the ends of the overhanging portions, and 65 m. high almost throughout the span of 300 m. Each girder consists of two members of chords connected by bracings forming isosceles triangles. The lower flanges of the two girders have a distance of 25 m. between their axes in the central span of 300 m., and an interval of 10 m. at the ends. They are horizontal in the center span, but are raised to a height of 5 m. at the ends of the cantilevers. The upper chords are connected in the largest portion of the central span, but diverge at a certain point, so as to be 10 m. apart at the ends, and this is also the case with the lower chords; in the cantilevers they assume the shape of polygons inscribed in a circle of 650 m. radius.

All the principal members of each girder, such as the chords and braces, are formed of plate and section iron divided into four segments. The secondary bars are of simple sections. The lower chords are square. They are 2 m. high at the central span, but decrease in weight toward the ends of the cantilevers down to 1 m. The upper chords have the same width as the lower ones, but as the segments of which they are composed are longer, their height varies between 3 m. and 1·50. The braces are square, and their size is variable, according to the open length. The distance between the principal lower apices of each girder varies between 50 m. and 6·50, so as to make up as far as possible for the difference of diction of the braces. The lower chords are connected by cross-shaped bracings, the bars of which are of hollow circular section. Cross bracings between struts of the two main girders give additional strength to those girders and increase their resistance to the wind.

Independent Span.—The independent span of 150 m. is formed of two girders resting upon the ends of the cantilevers. Their height is 11 m. on the supports and 20 m. in the center, their central spans being 10 m. apart.

Each girder consists of two flanges or chords, the lower one being horizontal and the upper one assuming the shape of a polygon inscribed in a circle, both being connected by web, forming isosceles triangles. The two flanges are formed of sheet and section iron divided into four segments of identical shape. Their common height varies from 1 m.—at the ends—to 1·50—in the center of the span. The web is of the same type.

The secondary bars are of simple section. The lower and upper numbers of the main girders are connected by cross-shaped bracings, the bars of which are of caisson section. Here also there are cross bracings corresponding to the struts of the two girders.

The Flooring Proper.—The two lines of rails are supported by four rows of longitudinal beams disposed parallel with the rails. These beams are latticed. Their height and span are unequal, and their dimensions vary according to the stress they are to resist. The rails are to be embedded in a groove to avoid accidents. The plates are formed of ribbed iron 8 mm. thick, weighing 50 kilos. per square meter. They rest upon ⌊-shaped irons. The footways are provided with balustrades fixed upon the overhanging ledges attached to the extreme beams. The horizontal beams under the rails are carried by transverse pieces, each of which connects two of the lower apices of the main girders. All these pieces assume the shape of a Warren girder with three bays. Their weight is variable, and the bars of which they are composed are of hollow tubular section.

(*To be continued.*)

* The segments and calculations relating to the superstructure for the contemplated Channel bridge were conducted by M. J. B. Pradel, managing engineer of the Chantier de Creusot at Chalon-sur-Saone.

STREET RAILWAY MOTORS OTHER THAN ANIMAL, CABLE, AND ELECTRIC.*

By HENRY H. WINDSOR.

THE subject of this report, which at first thought suggests a broad and inviting range, on examination is found to be closely defined. Instead of a fertile field the past years stretch out more like a vast desert; the wayside thickly strewn with bleaching, or rather rusting, skeletons of frames, cross bars, gears, pipes, levers, springs, and empty pocket books: while beneath the *debris* lie buried fond hopes and rosy expectations of some contrivance which at its birth was to wax great, and, going forth, subdue the land, and, as a lasting monument to its inventor, go thundering down the ages, around curves of small degree, up steep grades on the other side, and never slip a cog or miss a fare.

MOTORS.

Of these there are two kinds: motors and pro-motors; and of the two, it is no small question in most cases to determine which is the most impracticable.

Whenever a person invents—or thinks he does—a new motor, the very first place he heads for is a street railway office, where he proceeds to assure the manager that he has now "got it"—of which fact, judging from his wild talk and excited action, the manager has not the slightest doubt. But what has impressed the writer as curious in this connection is that in nearly every instance the originators of these motors, which are at one fell swoop to revolutionize the world, are in nine cases out of ten men whose only connection with a street railway has been in the capacity of a passenger, while some of them would be more at home on an ox cart than a bobtail even. Of the nine, possibly one can lay claim to anything like a practical knowledge of mechanics, and the rest will be found among the ranks of store clerks, country tinkers, and that class of impecunious gentlemen of leisure who would rather scheme and dream than work. With these people of one idea your objection, though mildly expressed, to glaring defects in their "invention," simply stamps you as narrow minded, and your refusal to be made suddenly rich through their efforts causes anguish of heart that is simply intense.

Even after these people have succeeded in building and testing their motor one must take their statements with a great deal of allowance, for it is the universal custom to figure out theoretical results and greatly in their favor as against operation by animal power. A trial is made under the most favorable circumstances possible, and the sanguine inventor sets out carefully selected results as the average or even minimum effort of what was actually the maximum. He too often overlooks all defects because to him they can all be overcome, and so, perhaps, on a trial trip of less than an hour, under every advantage of atmosphere, track and skilled assistants, the inventor announces another startling success. If it goes on a bit of track a block long, why not a mile, or forty? If for one hour, why not a week or a year? What the skilled engineer so perfectly controls, why cannot the necessarily unskilled labor that must be utilized in our everyday work accomplish? In short, a sort of everlasting youth, an almost perpetual motion in its simplicity and economy.

The pro-motor invents unintelligently. He looks only at what actual horse power can be developed and loses sight entirely of the thousand restrictions and conditions, such as extravagant wear of track, expensive remodeling of rolling stock, unsightliness, danger in operation, inability to control, and more than all else, absolute certainty of operation. All he looks for is something that will go, forgetting that a bank cashier will do as much under proper conditions. Past failures have also been largely due to the necessarily futile attempt to get something for nothing. It is not in the books and the Lord does not seem to be on the side even of the street railway man who attempts to get something for nothing. The precedent was early set when Adam gave up one good rib for his Eve, and the principle endures. Ten cents' worth of naphtha will not make a dollar's worth of hard coal steam; nor will a dollar's worth of soft coal compress air that shall at will rush out in ten dollars' worth of energy.

So much for pro-motors.

In this report technical terms have been avoided and the following descriptions make no pretense to scientific explanation and are treated in a very matter of fact manner, the aim being to get at the real, intrinsic value of the various methods as they stand related to our wants in the street railway service.

The forms of street car motors under this subject may properly be divided into four classes, and as to practicability in the following order, viz.:

1. Steam.
2. Gas.
3. Compressed air.
4. Chemical.

STEAM MOTORS.

With these you are all perfectly familiar. Letters of inquiry sent to two hundred of the principal companies throughout the country elicited reports from seventy-three companies, fifteen of which are using steam dummies. Of these fifteen, four only operate in cities, located, two in Alabama, one in Washington Ter., one in Montana Ter., and both the latter are now changing to cable. Of the eleven using motors on outside or semi-suburban business, only two recommend its use in cities; the other nine are most emphatic in their assertion that it is not a practical motive power in the business streets of towns and cities. All agree in the statement that costs for repairs are great. The operating expense, as compared with horses, varies widely, ranging from 40 per cent. less to 300 per cent. more.

Many of the dummies built by the Porters and Baldwins are practical, serviceable machines; for years are still doing good work. But they require a separate motor car, a skilled engineer, a self-cleaning rail, and their repair account, in common with other makes, increases and their general usefulness decreases in proportion as the line grades from a suburban one to the business of a city street. The dust and grit seems to take the life out of any motor with exposed machinery. In one city from which reports were received, several new standard steam motors had been entirely used up and one thrown in the scrap heap, all within the past fourteen months. Simply ground to pieces by the peculiar dust and mud incident to that city. On a country line they would have run for years.

Ransom, builder of the Ransom steamer, makes this one of his great claims, viz., that his working parts are all dust and mud protected, the cylinder driving directly on the car axle, and engine and boiler all carried on the passenger car.

But the use of the dummy is every year becoming more and more restricted. For extensions they may answer for a time, and for strictly suburban business are sometimes quite popular, but as the territory begins to fill and the roadway becomes a traveled thoroughfare, the objections rapidly increase. They scatter ashes, belching smoke if soft coal is used, and gas and fumes if steamed from hard coal, which also is expensive. Petroleum emits more or less odor. The unpopularity of the dummy cannot be better illustrated than by a line three miles long in Chicago, which had been in operation sixteen years, paying expenses only during the last three. This was replaced by a cable line, running at the same speed at which the motor had for years, and the first summer of its operation repeatedly carried as high as 50,000 passengers of a single Sunday afternoon; this, too, with absolutely no more attractions than had existed for years. People would not ride for pleasure behind the "dingle dongle," as they termed it.

From companies successfully operating steam dummies, the following are selected:

The Metropolitan Street Railway, of Atlanta, Georgia, are using several Porter dummies with satisfactory results, drawing as high as three hundred passengers at 10 miles per hour. The motors weigh 18 tons. Operating expense is 100 per cent. greater than by horses, but the increasing business has overbalanced the extra expense. The exhaust is visible, but not noisy.

W. H. Patterson, secretary of this company, writes: "The lines of this company run into the heart of the city, and we have so far had no great difficulty or serious accident resulting from the use of steam motors. The lines were formerly operated with horses. Since changing to steam, the company has been profitable to its owners; it never was as a horse car line. My experience is that steam motors are practicable to cities with from 100,000 to 200,000 inhabitants; but where population is greater, the danger would be too great for surface roads."

Another company in the same city, using a lighter steam motor on its suburban lines, estimates their operating expense twenty per cent greater than horses. Their repairs are heavy, and this company would not consider it desirable for other than suburban lines.

The Highland Avenue and Belt Railway, of Birmingham, Ala., have used a Baldwin dummy on the business streets for three years. Weight, eleven to seventeen tons. Speed, fifteen miles per hour. Work well on grades and curves, and draw three 35 foot cars. Repair expenses great; skilled operator required; steam vacuum brake is used, with good results.

The Prosser motor—you have heard more or less of this motor, of which Malcolm McDowell in an expert report says: "The Prosser motor consists of one high and one low pressure boiler, three steam cylinders, four for driving the driving wheels of two separate trucks, and two for working the pumps and air blast. The driving cylinders are coupled direct to the driving

* Read at the meeting of the American Street Railway Association, Minneapolis, Oct. 16, 1889. From the *Street Railway Gazette*.

wheel. The steam pressure on the piston head is the difference between the pressure in the high and low pressure boiler, and this difference is maintained by a surface air condenser, which takes the heat out of the exhaust steam as it leaves the cylinders, and the heat thus taken up in the air is returned to the fire box to maintain combustion, and is so much of the heat originally engendered then returned. The circulation of water between the high and low pressure boiler is maintained by a force pump working under the steam pressure from the high pressure boiler.

The one inspected by your committee was a car about thirty-five feet long, with a large upright boiler in the center of the car, which was carried on two swivel trucks. Hard coal fuel was used, being fed to the fire automatically through a central chamber in the center of the boiler, like a hard coal stove, and which carried several hours' supply. The low pressure boiler was to absorb the exhaust—steam and noise. The car, when fitted, was extremely heavy; the mechanism was complicated; some of the rods and pipes cleared the street by only two or three inches. The driver must stand in the center of his car, where it is almost impossible to watch his track. It is impossible to see wherein this motor affords any relief, and I am informed upon good authority that those who were backing the project financially have become discouraged and given it up.

A curious freak of mechanics has been testing on one of the Chicago City Railway Company's lines during the past two weeks. The motor consists of an eight foot flat car, a vertical boiler on one end, an engine that looks like a churn laid on its side, and about the size of a churn, with the handle sticking out and turning a gear wheel which meshes with a cog on the car wheel axle.

There is no noise, the engine reverses in a fraction of a second, and quickly attained a speed of 12 miles per hour on level track. It made a half mile run up a heavy grade in three minutes.

This engine is something entirely new in mechanics, the Patent Office recording that nothing like it is of record. It is an economical user of steam, is noiseless, takes no room, has no parts visible, and but few inside, is very cheap, and very powerful.

One the size of an ordinary butter churn would develop 15 or 20 horse power with 60 pounds of steam. We have great hopes of it, and it can be steamed from oil fuel, will be less difficult to operate than a team of horses, and can be carried on a passenger car or in a motor car.

STEAM STORAGE.

The question of steam storage is again being agitated, and a motor of this pattern is about coming out of the Pullman shops at Chicago.

The City Railway Company, of that city, experimented carefully for one whole summer with a steam storage motor, and with results entirely bad. Superheated steam was let into a boiler underneath the car, and a small dead fire placed beneath this tank to keep up its courage. The fire was allowed to burn until the start was made, when it was shut up like a tailor's goose. This fire was, of course, unnecessary; but made assurance doubly sure.

The writer has vivid recollections of alighting from this balky horse and plucking pickets from neighboring fences to get up life enough to make for a side track, where the machine expired and had to be towed home with horses. This occurred repeatedly. The car would die on the track at almost every trial. Steam storage can hardly come to our aid, for as long as surface roads are operated, they will be always liable to detentions from breakdowns of wagons, fire hose across track, and a thousand and one delays, which would tend to keep the motor out past the bed time, and it would surely slumber on the street. A motor capable of carrying sufficient steam to make an eight mile circuit would have to be built extremely heavy, the packing would have to be thick—expensive in its first cost, and expensive on the roadway. It would be complicated in construction, and subject to delay at end of line while being charged; which during the rush, morning and night, would work fatal delays. We can hardly pin our hopes to the steam storage.

There is much reason to hope that in the coming gas engine, several of which are now being developed, we may find that which we long have sought, and mourned because we found it not. The Connelly gas motor has been tried with success, so the inventor says, at Elizabeth, N. J., and we had hoped to have had one in Chicago in time to make careful experiments and report thereon, but the owners have failed to bring one west, though repeatedly promising to do so.

The Patton motor uses a gas engine, and the new one which is being built at Pullman is intended to operate continuously, running a dynamo on the car which is to charge a storage battery, which is to supply another dynamo underneath the car, which shall gear to the axles and everlastingly make things hum. That is the intention. It does not require very much study on the part of the ordinary railway manager to convince himself that a very few of such motors will suffice to equip his line. The original Patton motor built at the Pullman shops, and a very handsome piece of work, with its nickel-plated hand rails and Russia iron smoke stack, when tried in Des Moines last summer, failed to pull its train, and indeed could barely move itself—the motor car.

COMPRESSED AIR.

Compressed air is at present used quite extensively in Paris for stationary engines, which are supplied from pipes laid in the streets and drawing their supply from a large reservoir, which is kept constantly filled by immense compressors at a central power station. But what makes a most excellent power for stationary engines proves wholly inadequate as a means of independent locomotion.

High pressure involves great expense at first for plant, and much loss of power by reason of the friction in the compressing machinery. Leakages also, at all points, are great. Low pressure does not admit of a sufficient quantity to be stored and carried on an ordinary car to last for a greater distance than 500 or 600 feet.

Compressed air was used for three years during the construction of the St. Gothard tunnel. The engine weighed six tons, and the air reservoir was 45 feet long. It contained sufficient air to draw twelve loaded dump cars a distance of 2,000 feet, and return empty, with one charge. Pressure was 130 lb. at the start, and was reduced to 25 lb. at the end of one round trip. It was impossible to use fuel in the tunnel, hence the use of air, which but for the work performed would not be considered economical out of doors.

A recent American inventor aims to carry compressed air through a 4 in. main laid between tracks. This air is to be conducted to a reservoir in a moving car through a flexible hose placed at intervals of say three blocks, and suspended over the car by a heavy wire. One end of hose connects with the pipe line of compressed air between tracks; the other end has a sliding socket into which the pipe attached to the car fits and connects with an air reservoir placed beneath the car floor. The motor is placed on the front platform. A central power station keeps up the pressure in the main. Just how much pressure a car would receive at the end of a three mile pipe, when 50 or 100 cars between it and the compressing station were also taking their supply, is not stated, and the general idea of a car lifting up its head to receive its sustenance from a suspended rubber tube is so suggestively infantile in its operation that the plan, however pretty on paper, can never receive much attention from a practical manager. Even if the scheme could be made to work at all, it would not be as cheap as horses and nothing like as certain.

A very similar system was that so long advocated by Mr. George Pardy, of San Francisco (who died only a few weeks since). He proposed to use a central compressing station, forcing air through a 4 in. main placed between tracks. Every 500 feet this main was tapped by a plug or valve of 2¼ in. diameter opening at which the car driver could refill his tank. It was expected that the actual passing of the air into the car could be accomplished in less than ten seconds after connection had been made. Low pressure, 50 lb., was used to prevent condensation and freezing, but this necessitated the refilling of the car at every block of 500 feet. It is obvious the inability of any driver on the ever-varying condition of track to quickly stop at exactly the spot where the plug is placed. If he runs past he delays in reversing, and the time spent in making the proper connection must be fatal to the system. Then on dark nights the difficulty would be greatly increased, and during rapid snowfall almost impossible. Different temperatures and weather would affect the force. Any one who has attached an ordinary garden hose knows how much time that requires, and while the plug connections could be made to attach more quickly, still the unions would very quickly wear, and then would come loss from leakage. Mr. Pardy also contemplated a cable system for his air line, to get his air motors over grades. The system is not claimed for suburban work, and certainly is not adapted to the wants of metropolitan cities.

Still another project was that of the Pneumatic Railway Company, which is to lay a conduit of cast iron pipe along the track between the rails. A slot extends along the top of the pipe, through which steel bars connect the car with pistons which fill the pipe. This slot is covered from the inside with a flap of leather. Rivets, beeswax, and tallow are supposed to hold the leather in place and prevent the escape of air. As the car moves along, the leather is displaced by the steel bars. As soon as it passes, the leather resumes its position. Comment is unnecessary, although a patent was taken out and a company formed.

Mr. Louis Ransom, who has experimented for many years with compressed air and other motors, is still hopeful for success from the air motor. Under date of Sept. 30:

"Trouble in compressing the air appears from two causes. First, the great amount of heat resulting from compression, which burns oil and packing from cylinder and piston. Second, when pressure becomes high, unless the space between piston and cylinder head, at the end of the stroke, is made a complete zero, the air will not open the valve and pass out, but will cushion and play in the working space. These two difficulties may be mastered by a properly constructed compressor. The next problem is to hold this air after you have got it down, for it has a mighty trick of never getting tired. Of course good workmanship comes in here for all it is worth. We want a pressure of at least 600 lb. to the inch. That is easily enough obtained—but to hold it. No large reservoir will ever do here. It must be small and yet large. Small tubes have a marvelous power of resisting bursting strain. Two-inch boiler tubes are tested at the works to 1,600 lb. to the inch. Now at the power station I would build a receiver the size of a fair sized room of 4 in. boiler tubes, connected one with another. Into this reservoir air could be forced to 650 lb. Under the seats of the cars I would have similar magazines of small tubes which should be charged to 600 lb. from the stationary air receiver, by pipe connections, which should be made and unmade in a moment. This should furnish an engine which should use this air with parsimonious economy. But here another bother confronts us. If air gives out heat in compressing, it is equally willing to absorb it in expanding, and it has a knack of picking up any stray particles of water and freezing them into a solid lump of ice. Pass a pipe through a bath of hot water to correct this. One error which I think every experimenter in compressed air has made has been to 'wire-draw' their force.

"In other words, if they have in their receiver a force of 600 lb., let it pass a contracted throttle and let it touch the piston at 150 lb. If an archer wanted to fling an arrow 300 yards, and drew back the string until he had a pressure of 50 lb. on the notch, and then should let it up to 10 lb. before discharging the arrow, we should be apt to say something not very complimentary. What then shall we say of the mechanic who spends fuel to obtain 600 lb. of force, throws away 450 lb. of it, and uses 150 lb. only? Then wonder at the big percentage of loss. Air should be inducted into the cylinder at full receiver pressure. Enough air at 600 lb. can be chambered under the seats of a 16 foot car to propel nine miles, while about 60 per cent. of the compressing engines will be expressed in the cars."

Undoubtedly the above can be accomplished, but thus far all attempts have proved more theoretical than practical.

CHEMICAL MOTORS.

Of this class of motors there have been a number, but thus far all efforts to harness chemical power to street cars have proved miserable failures. It is the old story again, what will work in a closely guarded laboratory is powerless on so ordinary a commonplace as a street car. Little can ever be hoped from this source, as chemically produced motion has always been too expensive for purposes other than curious experiment. We beg, however, to call attention to one or two motors of this class.

Caustic Soda.—The remarkable ability of caustic soda to absorb and retain heat was accidentally discovered in one of the large soap factories in Germany, where the chemical was extensively used. Great iron tanks in which it was kept were one day being washed with hot water. A considerable quantity of the soda adhered to the sides of the tank, when the workmen were unexpectedly called away, leaving the hot water in the tank. Several days afterward it was discovered to retain a very considerable amount of its original heat. This suggested the idea of using a strong solution of caustic soda as a caloric to generate steam for street motor use.

In other words, use hot caustic soda under a steam boiler instead of wood or coal, the result aimed at being the fireless locomotive. One of these soda motors, known as the Honingman, was brought to Chicago in 1886, and placed on trial on a three mile track of the City Railway Co. Track was a standard gauge T rail, and was then operated on with a steam dummy. Everything was favorable to the trial. The test necessitated the construction of a good-sized cistern where the soda was stored, and from which it was pumped into a horizontal boiler, where it was heated over a coal fire. It was then drawn into the boiler of the motor, which was a vertical one, steam being made from water, and passing to the cylinders as in the ordinary steam dummy. Instead of the fire flues being filled with flame and smoke, these were filled with the superheated caustic soda.

The cylinders exhausted back into the soda tank, to prevent noise and save heat. As high as 60 or 70 lb. of steam could be reached, but on starting it quickly fell, and at the end of each trip the motor had to be refilled. This could not be done until the soda had first been all drawn off into the cistern. This demonstrated the fact that steam could be generated *en route* sufficient to run, without a spark of fire, ashes, gases, or audible exhaust. But while this was possible, it was far from practicable. Against it was the cost of maintaining the heating station, the extravagant use of fuel as compared with the force actually realized in moving the car, the expense of the soda boiler, which must be of best copper and able to withstand th chemical action of the soda.

While the motor was built in Germany, the engineer temporarily in charge was not, and the very first day the escaped soda on the floor of the cab was sufficient to eat his leather boots, which fell to pieces and burned his feet. While this might answer for a few hours for a man who wished to rid himself of corns, it is not a method which will commend itself to the general public. "Fare five cents and a corn removed with every ride" might do to advertise under certain circumstances, but while undoubtedly a drawing card, could not be expected long to please. Not only did the soda kill every spear of grass along the track for three miles, but the reservoir cistern was eaten through and the caustic percolated up through six feet of ground and sought the light in an adjoining lot, and the cherry trees, currant and raspberry bushes, and potato vines looked as if they had had the yellow fever, with unusually fatal results.

After a settlement had been made with the irate owner of the deceased shubbery, and a release in full secured, he felt better, but the proceedings taken all in all did not exactly commend themselves to the company. As a matter of fact, the engineer actually had to wear rubber boots all the time while on duty. The motor car was 12 feet long and carried no passengers. The motor also was extremely hard on track, being very heavy. The trial lasted several weeks, under every possible advantage, the inventor or his representative being present. The machine frequently died on the road and had to be towed in. If the pipes or boiler flues were allowed to cool while containing soda, they became filled with a substance as hard as rock, and had to be replaced with new parts.

A chemical motor known as McLaughlin's chemical motor was started with great flourish of trumpets last spring at Omaha, but a diligent search and numerous inquiries failed to establish more than the fact that it is enjoying a beautiful state of innocuous desuetude.

P. J. McMahon, in the city of New Orleans, in 1886, ran an experimental fireless locomotive, using ammonia gas as a motive power. This gas was produced at a retort centrally located, which supplied each car with sufficient gas to make a round trip, the gas being stored in an iron tank beneath the car or under the seats.

It was utilized through ordinary cylinders, same as steam, and exhausted into a tank of water, which absorbed and retained it for further use, water having the ability to absorb 700 times its bulk of ammonia gas. But the plan was abandoned as impracticable. It was not as cheap as the mule power, and no more certain. The gas leaked; the compressing machinery was complicated and its operation expensive, and too much time was required to charge a car.

Time will not permit to mention more of the many freaks of the would-be motors. There was a New Orleans man who firmly believed that he could get a spring big enough and wind it with a steam engine tight enough to run a car ten miles.

Another freak in the motor line is what we might term the "bovine motor," such as was actually seen by a member of this association when in Texas a few months ago—a 12-foot car drawn by a cow, and driven by a twelve year old darky, who sat on the front dash with his feet over in front.

This system has several advantages: Company's tickets could be redeemed either in rides or a quart of milk, and thus make the road a money earner night and day. There would be no shoeing account; no anxiety from split hoofs; the lowered horns by day and the big eyes and bellow by night would effectually scare away the small boy who delights to "hitch on." When old age began to creep on apace, instead of charging to depreciation two-thirds of the original cost of the animal, it could be slaughtered and sold over the company's own market, when again car tickets would buy soup bones, and the hide and hair yield their revenue in due season.

While the cow line may never be adopted in the slow-going cities, it might be made a great factor with proper management which companies contemplating a change in motive power should not overlook.

Then there's the car starter. Some present may have already heard of them. The only practical car starter is the one which will start a car on a three-mile track, and keep it started, until it has made six miles, with the necessary stops for passengers.

IN CONCLUSION.

There is no brighter field to-day to the studious inventor than a reasonably cheap motor, which will operate without smoke or noise, at a less expense and better speed than horses, which we can use on outside lines of large cities and on the entire system of smaller towns.

For a tremendous volume of business there is nothing like a cable car, and electricity is making strong claims for its place, but there are thousands of miles of car tracks in this country which are waiting for a practical and economical motor.

And the really practical man who invents a really thoroughly practical machine will be welcomed in a way that will place him beyond the confines of the poor-house.

Let us then watch, and study, and hope, and live in the expectation that ere another year rolls round and gathers us once more around these topics, the question may be in at least a fair way to solution, and our bondage to animal power and its bondage to our work be a thing of the past.

A VISIT TO HUELVA AND THE THARSIS COPPER MINES.

HUELVA is not much of a place as far as the town goes, being very small indeed, and there is a very ancient and fish-like smell pervading the whole place, although the streets are clean enough. There are only three principal buildings, two churches and a theater, and they are hardly worth looking at. The houses, unlike those of Genoa and Savona, are very low, built of stone (rough), and plastered over, and simply whitewashed, and never, or very rarely, rising to a height of three stories. The central post offices (or correos) are simply a medium-sized letter box let into the wall of a house; stamps are bought at the tobacconists, who also have a letter box on the counter. It is the funniest arrangement of posting that I have ever come across. The letters are collected by postmen, who fill their pockets with them, and the surplus they carry in their dirty hands; have no bag at all, so that I do not wonder at so many being lost. It was my first and my last visit to the town.

They have no *specialité* except the curious water and wine bottles of clay and terra cotta. The cafes for the most part are rather shabby-looking places, and the frequenters sit on chairs, which are ranged along the gutter facing the cafe. And at almost every corner of the principal streets there is a hideously contorted cripple begging. The sight of some of these fairly made me feel sick. We went by rail to view the Tharsis copper mines, which are at a distance of 35 miles from Huelva, taking 2 hrs. 10 mins. to complete the journey by rail.

We started at 3:30 P. M. from Coralles. Our train consisted of three carriages hooked on to the end of a mineral train, and we had a terrible jolting and shaking, and the country we passed through was very barren and uncultivated, no tall trees, and very few houses, most of which were simply little thatched huts, built of wood and straw. But now and again we could see a cultivated acre or two, which were very refreshing to the eye, being like oases in the midst of an undulating desert of barrenness and sterility. The hedges are formed of either stone or that long-leafed species of cactus, they call them "Peters" here, but I cannot get to know the proper English name. There is plenty of the white heather, which is so rare in Scotland and England, and which grows to the height of 5 or 6 feet, and a good many of the wild fig trees, which are very low and appear like shrubs, but as we neared the Tharsis mine we could not see a single sign of vegetation. Even grass was nowhere to be seen, only coffee-colored hills as bare as they could possibly be and very rough and stony. The sulphurous smoke of the mine destroys all vegetation, and it was this fact that gave rise to the trouble on the Rio Tinto mines some years ago.

The Tharsis mines are very extensive. We were met by the commercial manager, who has under him a whole staff of managers of the different departments, and who are nearly all Scotchmen, and these men have their quarters quite separate from the workmen. The bachelors live by themselves, in one row of houses, and the married men in another, all low houses, only ground floor, but very large rooms and handsomely furnished, and a good row of trees, flowers and plants, as they are right away from all the smoke, and the gardens are very attentively seen to. The church has no pews, but chairs ranged round, with a table in the center with books, magazines, and papers, forming a club, reading room, and church. The vestry contains a billiard table, in fact is nothing but a billiard room, and next to that a store room, where they keep wine, beer, and spirits.

It is quite a Scotch colony, and all the men are very sociable and jolly, and I did not hear one single word of bad language. After six o'clock dinner, in a spendid house set apart for our own use (Capt. Forsyth, myself, and fellow voyager), we were conducted down to the village, the palazzo, casino, and workmen's club, which was built by the workmen themselves and at their own cost, and is the finest workmen's club I have ever seen anywhere. The village contains 6,000 inhabitants, all employed on the mines, and the whole of the ground, houses, and plant belong to the company. The managers are the judges, magistrates, etc., and have all the law in their own hands. The extremity of their law is dismissal in twenty-four hours' notice. Any one fighting, using the knife, or becoming a confirmed drunkard, has to leave house and property all behind, and go right away, as there are no works or even village for several long miles. They have a strong force of police and soldiers, a splendid hospital, with a Scotch and a Spanish doctor, large schools with Scotch and Spanish schoolmasters. It is the most orderly village I have ever seen, as the fear of dismissal makes men keep well within the bounds of temperance and quietude. And they are very polite; but of course this state of things has only been arrived at after a considerable time and amount of trouble, as the Spaniards are, as a rule, very fond of using the knife, and very quarrelsome.

Next morning we were up at five, and had coffee about six, after which we were provided with horses, and set out for the Esparanza mine. But my horse was very frisky indeed, and after awhile he bolted, and I had a regular John Gilpin ride; but I managed to keep my wig on, although my hat was gone, and a miner passing at the time ran up the road as fast as he could go after my hat, but never thought of trying to stop the horse, which I only managed to pull up when we had reached the head of the mine. The others were screaming with laughter, although they were as concerned as could be, and almost as white as myself. I dismounted, and having arrived near enough we walked the rest, and had a good look at the mine, the blasting, digging, and carrying of the minerals to the wagons, which is performed by women and girls, and who carry in the course of the day from 20 to 25 tons of mineral on their heads from the side of the gallery to the wagons.

This was the Esparanza mine, where they get the "schist," which is a form of slate impregnated with copper, and which is simply washed by means of placing in level beds over which the water runs into channels or gutters for about two miles. The water collects all the copper, and it is deposited upon bars of pig iron placed in the gutters. This forms the pure leaf copper. I have not time to go into all the details that I should like. It is certainly the most interesting sight I have ever seen. I got a quieter horse when we returned, and was perfectly safe and contented. We next visited the North Load mine, where they get the copper ore and the mineral. We donned the miners' clothes and descended the shaft to the depth of 250 feet. At the bottom is the copper ore, and from the underground galleries higher up they get the mineral, which only contains about 3 per cent. of copper, 46 of iron, and sulphur, arsenic, and several others, which is placed in heaps and the sulphur burnt out, and afterward undergoes the washing process.

They have plenty of water, the mines being at the source of the river. We went though all the underground galleries, and saw the Roman workings and galleries and overhead a Roman grave and several houses, or rather the remains. I am told that this is Tarsus of the ancient world. The women carrying the pitchers to the well remind me of the Bible pictures of Rebecca at the well. We were conducted over all the mines and all the workings and processes, and through the shops also; and what with the heat, the horse, and the rough road I was fairly knocked up, and very glad to get into the train again at 3:45 P. M. We arrived on board ship about 6:30 utterly worn out, but delighted with our visit to the mines, being an unexpected treat for me. The manager wanted me to return next year and give a full description and illustration of the mines, as they are the most extensive copper mines in the world. I do not think it has been done before.—*Newcastle Daily Chronicle.*

LIFE IN DENMARK.

OLE CHRISTIANSEN, a remarkably intelligent Danish farmer, has just returned to the United States after a visit to his native land, the first he has made since he emigrated, twenty years ago. His experience has made him well contented with his adopted country, and he has no longings to live again where the condition of the common people is so appalling and hopeless.

"I spent the most of the time with relatives who live on the island of Lolland, in the North Sea. It is about twenty miles long by fifteen in width, and the soil is extremely rich. Every inch of it is cultivated, which is the case throughout the entire kingdom. Here, however, the yield is heavier than upon the continent; the grain lies on the ground with its own weight."

"What are the chief products?" he was asked.

"Wheat, rye, and potatoes. Not many potatoes are raised, as the season is too short for them to mature well."

"They work the soil much more than American farmers do," he explained. "Labor is so cheap that they can turn it over many times, until every clod is broken up and every pebble removed."

"Is much machinery used?"

"Very little; the farmers are too poor to buy it, and laborers can be hired in such numbers and for so little that it would not pay them to invest largely in mowing machines and twine binders. Almost everything is done by hand, and even then laborers are out of work half the year. Wages are extremely low."

"What is the average?"

"Women receive about $12 a year, with wool enough for their stockings. They work out of doors like the men during the spring and summer, helping in the fields and in the dairy. Butter and cheese making are carried on extensively. In the winter they spin and weave, as all the clothing is made at home from wool raised on the farms. Shoes are generally bought, but not always. They have thick wooden soles, with leather over the toes, and are roughly nailed together. They are frequently made at home."

"What wages do the men receive?" was the next question.

"About $50 a year, but this can be earned only by a first-class laborer. Very few receive so much. Two hundred crowns is considered good pay, and 200 crowns is about equivalent to $50 in United States currency. The coin most in circulation is the *ore*, about one-fourth of a cent. Danish laborers cannot, or do not, work so fast as Americans, but their hours are much longer—from four o'clock in the morning until ten at night is a day's work. Of course, in that northern latitude, the greater part of the year, much of the work must be done by candle light. In the winter the sun does not rise until nine o'clock and sets at three. The people use candles exclusively, and make them of tallow."

In regard to the food he said: "The usual fare of even well-to-do farmers is coarse bread made of unbolted rye. Wheat bread is a luxury, and is used like cake in this country. Very little fresh meat is to be had—only about once a month or on holidays. In the winter salt pork is eaten, and geese are raised in large numbers and the meat salted down, and this is about the only change in the diet they can have. Geese can feed themselves and are easily raised.

"There is one thing that is universally used and is always good; this is malt ale. The farmers take their barley to the mills and have it made into ale. It is sent into the fields, and is drunk instead of water. Most of the men take a small glass of whisky with their dinner, but drunkenness is almost unheard of, especially among the poorer people. A drunken man is rarely seen. Of course, the nobility drink to excess frequently, because they can afford to."

In regard to the general appearance of the country, he said it was level and under the highest cultivation everywhere.

"The roads are magnificent, as smooth and clean as the sidewalks along Michigan Avenue. They are bordered by clipping hawthorn hedges, and the strips of grass on either side are shaved like well-kept lawns in this country. Then everywhere along the highways fruit trees, mostly apples and pears, are planted, which are free to everybody. The fruit is of a peculiarly fine flavor. I think the moist sea air has something to do with this. The highways are tended like gardens. Every weed is cut out with knives, men and women being constantly employed to do the work. They get only a few *ore* a day, but are thankful, even at that, to have the employment. There are forests of beach and birch, and the whole country is brilliantly green from spring till fall with verdure which has the brightness of our grass and foliage in June.

"The farmhouses are all of stone, the roofs thatched with straw. None but the rich can afford slate or tile roofs. Where the servants wash, the floors are of clay; in the other rooms they are of wood, well scoured, and the wealthier people have mats spread about.

"The people, of course, are Lutherans, as that is the state religion. Everybody goes to church, and in the thinly populated region they come for miles around. The services begin at eight o'clock and continue until ten, and the hours are the same throughout the year. The pastor does not take a vacation. He is a man of great authority, and the people have to obey him. If he is good, they like him; but if he is overbearing and insolent, as even preachers can get to be if they have their own way too much, they hate him. But, whether they like him or not, they cannot dismiss him, and must pay him his salary."

"What are the recreations and amusements of the people?"

"Oh, notwithstanding their poverty and unceasing toil, they are wonderfully merry and light-hearted. It is probably because they have never had their contentment marred by contrasting their situation with a more prosperous one. They are all poor alike and poor together. They do not know of any other possible condition. The harvest parties and May parties and Christmas are the three great holiday occasions, and they feast and dance and sing and play cards. The people everywhere are the soul of hospitality, and the stranger who stops to rest or to ask the way is always welcomed and given bread and coffee, or whatever they may have to offer. When a child is born, cakes and meats and other delicacies are sent in by friends and relatives, and there are eating and drinking and visiting for several days. All the acquaintances and kinsfolk call to offer congratulations, and these attentions are always scrupulously returned in kind.

"When any one dies the body is kept for eight days. On the evening of the seventh day three men, appointed, examine the body carefully to see that there are no signs of life. The climate is such that th body can be kept for a great length of time. On the day of the funeral there is a great dinner, to which all the friends and relatives are invited. They have wine and cake, all kinds of soup, meat and fish, served in courses. This is after the burial, and it is very often continued through the ninth day, when all the children are invited. Nothing is sent in at funeral feasts, as at births and christenings.

"At weddings the eating and dancing last three or four days, and are paid for by the father of the bride.

"Nevertheless," he continued, "the poverty of the people is oppressive. It is chiefly due to the custom of dividing estates. Large families are the rule; ten or thirteen children the average, and there is no possible chance for them to find employment by which they can earn their own living, as they might in this country. The father, if he does not wish to see them go to the poorhouse, must give each a share of what he owns. The farm is transferred, during his life time, to the eldest son, who cultivates it and pays to each of his brothers and sisters the allotted share. The parents finally become impoverished and dependent, whatever they may have had when they were married.

"No girl can get a husband unless she has a dowry, no matter what her personal attractions may be. Affection or suitability have very little to do with the contract. It is a very common practice to marry very young girls to old men who have money—they are literally sold.

"I will give you an illustration of how the division of property works. My father gave all he had to his oldest son. There were six boys and four girls. When my brother took the land, it was worth $20,000. He afterward sold a piece of marsh, which increased in value, for $13,000, and his wife brought him a dower of $25,000. Fifty thousand dollars in Denmark is a great fortune, and he was regarded as a very rich man. The property, however, was in turn transferred to the oldest son. He had a small family—only four children—but the payment of a share to each, and dowering the daughters, left but little for any one of them. The son who now holds the land works early and late to pay the interest due to the others, and can never save anything or get ahead. My brother—his father—is seventy-three years old, and is blind, but he must get up at four o'clock in the morning and work until ten o'clock at night, because he had to give away what he accumulated when he was young and vigorous. I am very thankful that my father had so little for me that I was forced to emigrate to the United States. I have made, with not much difficulty, enough to keep me comfortably in my old age.

"Taxes are an intolerable burden," he continued, "in Denmark, as they are in all European countries. Everything is taxed. There are church rates, road taxes, school taxes, and other taxes that cannot be enumerated. The minister has to be provided for, and the nobles are supported by the people. They drain

the very life blood out of them. If a man wears a pair of high boots that cost $10, they are taxed; so is all clothing. When the tax collector comes around, a woman must lay out every garment in her wardrobe, let him make an estimate, and say what he demands.

"The Swedes keep the people poor. They are strong and hardy, and work for almost nothing. There is one part of Sweden where the people live on bread made partly from the bark of a tree. Girls come to Denmark, and are now hired by the farmers in great numbers, because they can be worked like slaves."

Mr. Christiansen said that although life was hard for the middle classes as compared to other Scandinavian people, few emigrated.

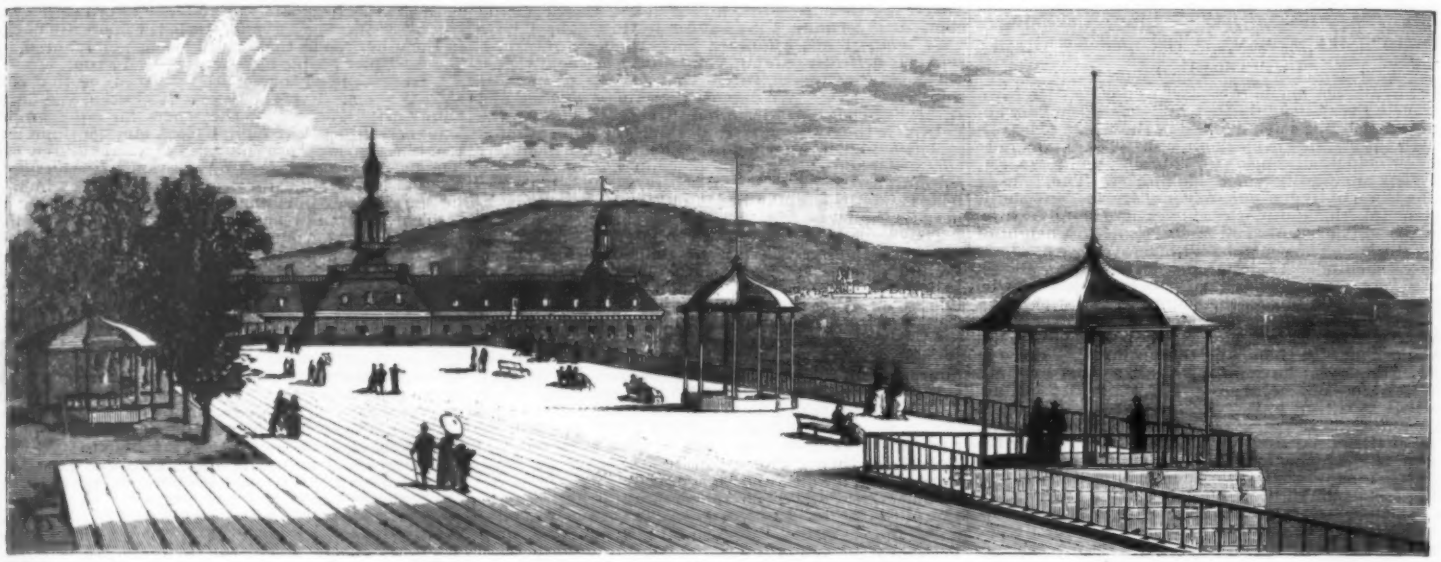
"They are very conservative," he explained, "and will not come to the United States so readily as the Swedes or Norwegians, because they must adapt themselves to new customs and surroundings which are distasteful to them. They do not look ahead, however, and consider the welfare of their families. Those who come—I am referring to the middle and lower classes, of course—are the most progressive and intelligent, and these, as every one knows, make good citizens."—*Inter-Ocean.*

THE RECENT LANDSLIP AT QUEBEC.

A GREAT disaster took place on September 18, at Quebec, on the river St. Lawrence, the capital city of Lower Canada. On that day, about eight o'clock in the evening, several thousand tons of rock slid from the face of Cape Diamond, at the end of Dufferin Terrace, below the citadel, falling 200 feet upon Champlain Street, in the Lower Town, carrying down seven dwellings, and covering the street and houses below with a mass of debris 300 ft. long and 15 ft. to 25 ft. deep. It had been constantly raining for several days, following on hot, dry weather, which it is believed made the cliff crack, and caused the disaster. A similar slide occurred in 1841, almost at the same place, when thirty houses were destroyed, with seventy occupants.

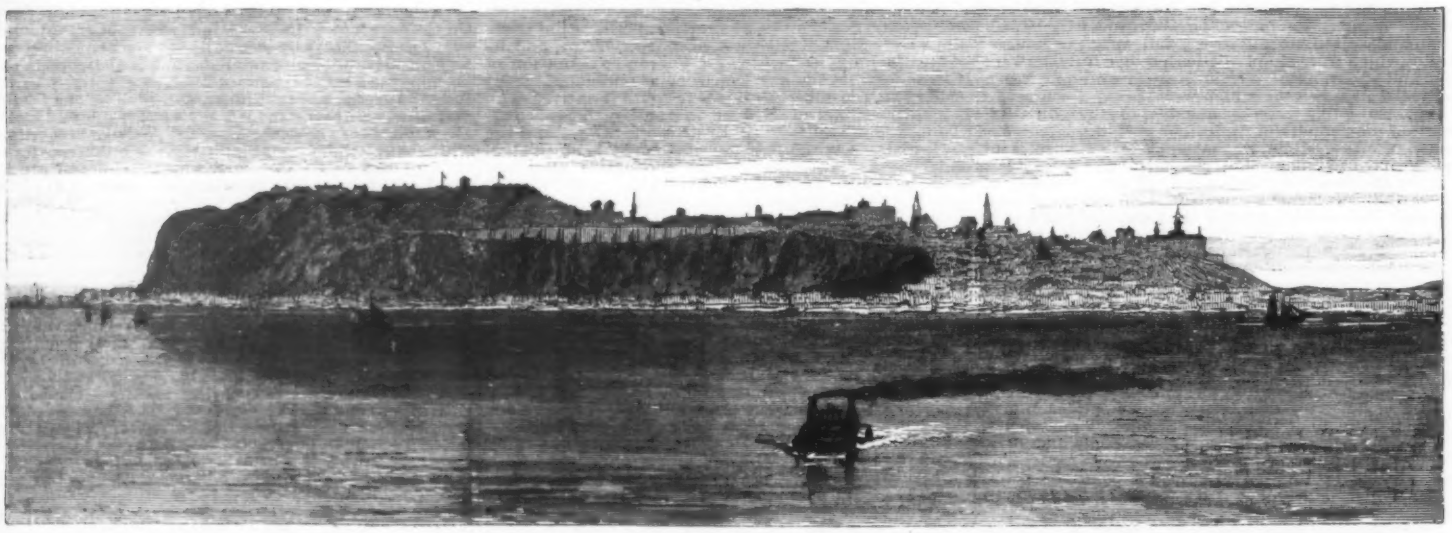
The work of rescue proceeded throughout the night, troops, firemen, and citizens aiding, six hundred laborers diligently working in removing the rubbish. The landslide left a large hollow space under Dufferin Terrace, making it unsafe. The houses destroyed were small, and were occupied by the working classes. Forty dead bodies were got out of the ruins before September 21. The condition of the adjacent cliff is still dangerous, and more slides are feared. The Canadian Military Board is making an examination to decide about supporting the citadel over Dufferin Terrace by walls protecting the cliff front.

Our views of the locality are from sketches by the Rev. W. C. Bourchier, Chaplain R. N., given in the *Illustrated London News.*



DUFFERIN TERRACE, QUEBEC.

× Place where the landslip occurred.



GENERAL VIEW OF QUEBEC.

LION HUNTING IN BIRMINGHAM.

THE eastern suburb of Birmingham was recently the scene of a protracted and exciting lion hunt, which resulted happily without serious casualty in the recapture of the runaway animal. In connection with the local celebration of the Michaelmas fair, Messrs. Wombwell had established their well known menagerie on a piece of waste ground known as the Old Peck at Aston, where the caravans were drawn up in a hollow square. One of the cages contained a young black-maned Nubian lion about four years old, which arrived in Birmingham from Liverpool only that morning about midday. The keeper entered the den to clean it, and while engaged in this duty his attention was momentarily diverted by a fight between an ostrich and a deer. When he looked round he found the cage empty, the lion apparently having slipped out through an opening in the side of the den caused by the displacement of a movable wooden shutter. The fastening of the latter, it seems, had been withdrawn by an elephant in the adjoining den. The lion, having passed unobserved under the caravans, presently found itself on the fair ground. At first the animal seemed quite bewildered with the noise of the people, the blare of the steam trumpets, the clashing of the cymbals, and the bellowing of the organs, and it remained for some time rooted to the spot. The people were too busy to observe it until the alarm was given by Wombwell's men, who hurried to the spot armed with ropes and iron bars, when a scene of wild confusion ensued. Men, women, and children scampered off in all directions as the lion dashed across the ground, hotly pursued by the men from Wombwell's. A group of children were in its path, but it cleared them at a bound and made straight for the neighboring brook. After wading up the stream for about fifty yards the panic-stricken animal, seeing its pursuers close at hand, appears to have crept into an open sewer, where it temporarily disappeared from view. The drains to the right of the brook had been explored for several hundred yards in every direction without any success, when Marcus Orenzo, the chief lion tamer, heard the fugitive lion roar. He traced the sound with difficulty to the channel leading from the manhole at the junction of the road to the outlet in the brook where the lion first entered, and he at once arranged to crawl through the drain in pursuit of the beast. A transfer cage was obtained and taken to the brook, when the drop door was lifted and the mouth of the cage placed against the opening of the drain. By this time Orenzo had changed his clothes, and armed with a heavy revolver and accompanied by a boarhound he descended through the manhole into the sewer. Twice in quick succession revolver shots echoed through the underground passages, and to the daring explorer the animal's roar showed that he was on the right track. Crawling along, Orenzo at length caught sight of the animal, which at first turned to bay, but quickly fled at the discharge of the revolver and made toward the cage at the other end of the sewer. The lion tamer crawled after it with all haste, and the faithful boarhound kept close at hand. When the mouth of the cage came in view, the dog was sent to the front, and at the word of command gave vent to a deafening bark; almost simultaneously there was a scrambling noise in the underground channels, and in another instant the lion bounded into the trap set for him, and was promptly caged and carted back to the menagerie.

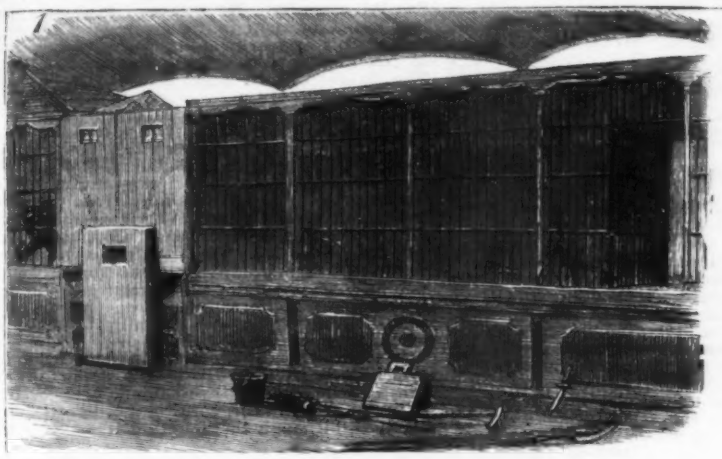
The London *Times* correspondent writes: In the small hours of Sunday morning a second desperate lion hunt was conducted through the sewers of Aston, but this time without the knowledge or presence of the general public.

It seems that the Nubian lion which was recaptured at the sewer outlet in Aston Brook on Friday afternoon was not the only one that escaped on that day from Wombwell's menagerie; but the proprietors of the show thought it inadvisable to take the public into their confidence on this subject, and they took measures privately to intercept and recapture the runaway animal.

Beyond placing a watch at the sewer outlet, however, nothing was done until a late hour on Saturday night, when, the assistance of the police having been obtained, active preparations were begun for recovering the lost lion.

In the first place, the fair ground near the sewer outlet was cleared of people shortly after midnight, and a trap cage was placed over the outlet. The manager of the expedition then proceeded to the nearest manhole. As the negro lion tamer, Orenzo, did not care to repeat his daring exploit of the previous Friday, two young men belonging to the working staff of the menagerie volunteered to descend into the sewer, which they did, armed each of them with a six-barrel revolver and a policeman's lantern.

Traces of the lion were soon found, and his roar was distinctly heard, but at a distance farther up the sewer. The young men then reascended, and the party proceeded to a manhole further inland; but here again they were on the wrong side of the lion, and it was not until they came to the junction of the sewers in Bracebridge Street that they got fairly on its track. It was then determined to trap it on the spot instead of driving it to the outlet, and with this object the manager of the party lowered a stout looped rope with a slip-knot in such a manner that the lion, in issuing from the neighboring sewer, would inevitably run into it. Then the two young men descended the next manhole and proceeded to drive the lion through the narrow pipe toward the looped rope. This was not accomplished until they had discharged all their



THE EMPTY CAGE.

CLEARING THE FAIR.

ASTON BROOK—SHOWING THE ENTRANCE TO THE SEWER WHERE THE LION TOOK REFUGE.

MARCUS ORENZO IN THE SEWER.

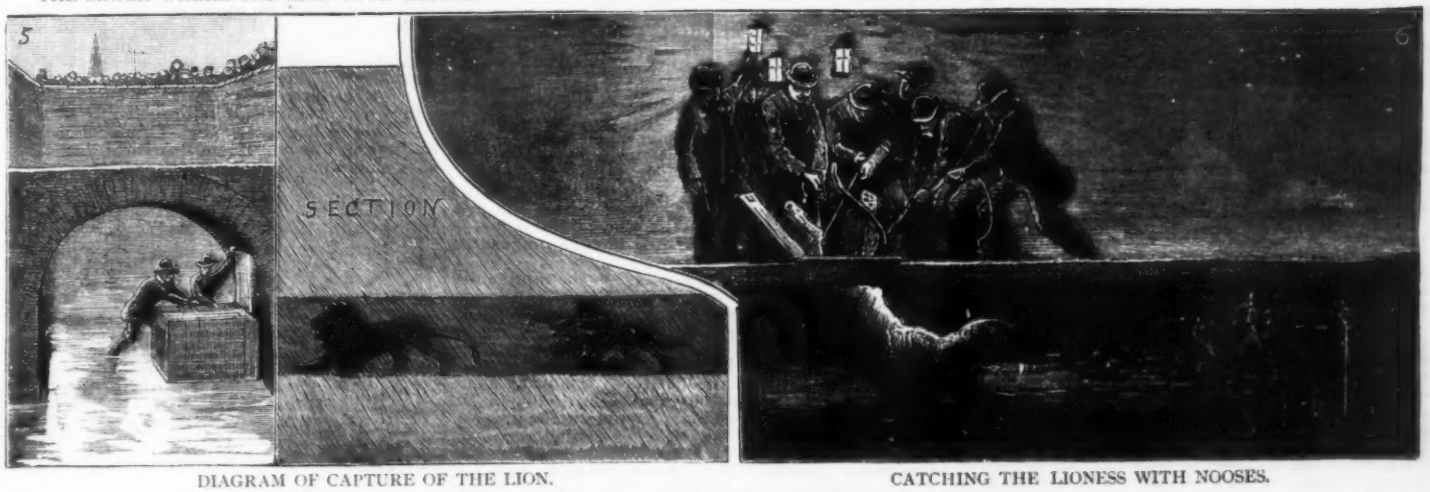
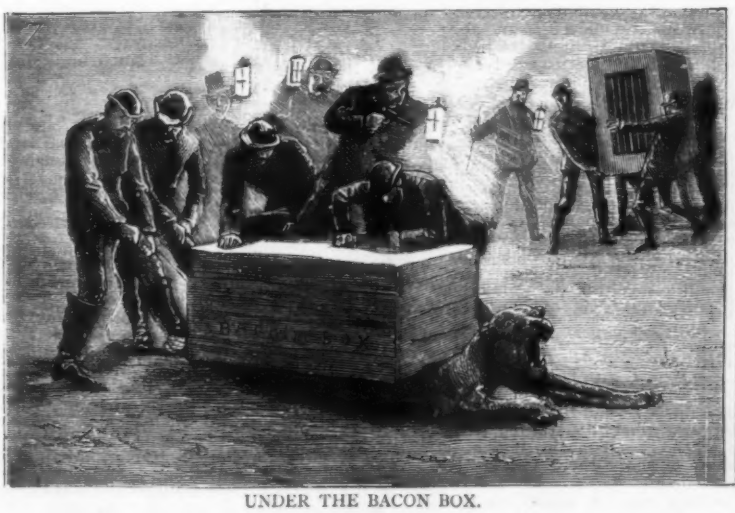
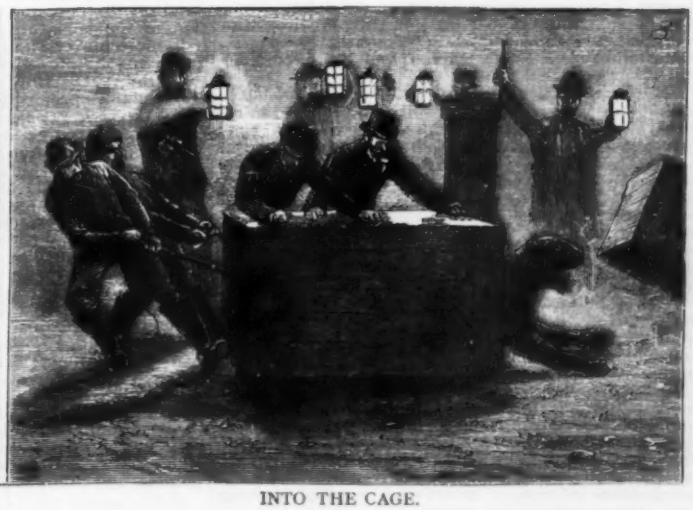


DIAGRAM OF CAPTURE OF THE LION.

CATCHING THE LIONESS WITH NOOSES.



UNDER THE BACON BOX.



INTO THE CAGE.

THE ESCAPE OF LIONS FROM THE MENAGERIE, AT BIRMINGHAM.

ammunition, and had been compelled to take off a boot with which to strike the sides of the sewer and frighten the animal in the direction required.

Presently a prolonged howl informed them of the success of their tactics. The lion had stepped into the noose, which fairly encircled his loins. In the meantime the people at the top of the opening pulled desperately at the rope until the animal was raised nearly to the level of the road, when a trap cage was placed over the manhole and the lion, more dead than alive, was dragged body first into it. Unluckily, the cage proved too small, and the lion, still roaring lustily, lay for some time in the road with the cage held over it by ten men, but with its head outside.

After a delay of about ten minutes another and larger cage was obtained, and into this the poor brute was eventually dragged and forced, by the application of many blows with iron rods, and carted off to the menagerie. Our illustrations are from the London *Graphic*.

THE INTERNATIONAL CHEMICAL CONGRESS.

AN International Chemical Congress has just been held in Paris under the presidency of M. Berthelot. The congress was composed of some 300 members, including the most eminent French chemists and a certain number of distinguished foreigners. It was much regretted that foreign countries should not have been more numerously represented, and it was explained that, owing to the protracted illness of M. Hanriot, secretary of the Paris Chemical Society and of the congress, the invitations were not sent out until very late, and still further delay was caused by their passage through the Ministry of Public Instruction. Much credit is due to M. Fauconnier, who undertook to replace M. Hanriot at the last moment.

The opening meeting was held on the 29th ult. at the Conservatoire des Arts et Métiers, the proceedings being of a purely formal character. M. Berthelot, who occupied the chair, said that a large number of communications had been received by the organizing committee, and that from the nature of these communications it had been found expedient to divide the congress into four sections, which he proceeded to enumerate, together with the list of sectional presidents and secretaries proposed by the committee :

Section I. Analysis of food products: President, M. Riche ; secretary, M. Bishop.

Section II. Analysis of agricultural products : President, M. Joulie ; secretary, M. Demoussy.

Section III. Analysis of pharmaceutical products : President, M. Petit ; secretary, M. Bocquillon.

Section IV. Unification of chemical nomenclature : President, M. Friedel ; secretary, M. Bouveault.

The sectional meetings took place in the day time ; the evenings of July 30, August 1, 2, and 3, being reserved for the discussion of the reports presented by the various sections.

Section I.—The section discussed a certain number of methods used in the analysis of flour, bread, wine, coffee, etc. At the general meeting the following resolutions were passed :

(1) That the government be requested to inspect regularly the factories of salted meats, as at present the brines used are added to constantly, but never changed (report by M. Combes).

(2) That the government be requested to inspect all teas on their entry into France.

(3) That not more than 0 3 per cent. of lead should be permitted in the alloy used for "tinning," nor more than 5 per cent. in the alloy for tin vessels.

(4) That it is desirable that the methods of wine analysis should be verified and codified.

Section II.—After discussion of the methods at present in use for the analysis of earths, manures, etc., it was resolved that in the case of judicial disputes no single method should in any case be obligatory,* but that the fullest latitude should be allowed to the experts.

Section III.—It was resolved that a certain number of permanent commissions should be appointed for the inspection of some of the most important substances used in pharmacy—quinine, morphine, chloroform, phenol, salicylic acid, analgesine, etc. The commissions should endeavor to investigate and improve the methods of analysis used for these substances.

Section IV.—Section IV. was the one of by far the greatest general interest, as was testified by the presence of Profs. Alexeieff (Kiew), Calderon (Madrid), Franchimont (Leyden), Graebe (Geneva), Istrati (Bucharest), Noelting (Mulhouse), Boukowski Bey (Constantinople), and Colonel Da Luz (Rio Janeiro), who were elected vice-presidents.

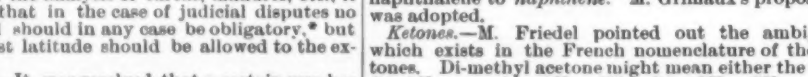
The following is a short account of the discussions held at the sectional meetings :

The Nomenclature of Unsaturated Hydrocarbons.—M. Calderon read a paper, in which he proposed to replace the present arbitrary names of the hydrocarbons by a series of names derived from the fundamental terms of each series. He proposes to name paraffins *protomethane*, *deuto-methane*, etc., the olefines *deuto-ethylene*, *trito-ethylene*, etc. The radicals are derived from the hydrocarbons by the insertion of Latin numerals between the Greek numeral and the generic name ; thus, methyl becomes *proto-uni-methane*, etc. The author advocated these changes as calculated to facilitate the teaching of organic chemistry. MM. Friedel, Grimaux, Graebe, and Maquenne expressed the view that it was impossible to make changes so radical, and that Hofmann's nomenclature was quite sufficient so far as the normal hydrocarbons are concerned.

M. Béhal presented a report to the section on a system for the nomenclature of complex open chain compounds. He regards them as formed by the addition of characteristic groups (*groupements fonctionnels*),† in which certain atoms of hydrogen are replaced by various radicals. These radicals are given in the order of the number of carbon atoms they contain, starting with the lowest. To denote different isomers the Greek letters, α, β, γ, δ, are employed. One or two examples may be given. The body

$$CH_3—CO—C\equiv C—CH_2—CHO$$

would be called acetyl-acetylene-ethaldehyde (acétyl-acétyléne aldéhyde éthylique). The body



would be called acetyl propionyl allene* methyl formic acid. Many objections were raised to M. Béhal's proposition by MM. Friedel, Graebe, Grimaux, and others, and it was finally decided to refer it to the permanent committee.

Derivatives of Ethylene and Urea.—M. Graebe proposed to denote the two atoms of carbon in ethylene derivatives, united by the double bond, by the letters, *a* and *b*. If two similar radicals are introduced into the ethylene molecule, as, for example, in dimethyl ethylene, the two isomers would be called *ab*-dimethyl ethylene and dimethyl ethylene, or for greater clearness *a*-dimethyl ethylene. In the case of trisubstituted compounds it should be understood that the first two radicals were linked to the same carbon atom. M. Franchimont proposed to adopt the same nomenclature for the urea derivatives. Attention was drawn to the possibility of new isomers, if Wislicenus' extension of the Van 't Hoff-Lebel hypothesis should be proved to be of general application, but it was decided for the present not to number the four atoms of hydrogen in ethylene, and M. Graebe's proposition and M. Franchimont's rider were adopted.

Aldehydes.—M. Grimaux proposed a resolution recommending that in future aldehydes should be named after the corresponding alcohols, and not after the acids. He pointed out that this usage was consistent with the etymological origin of the word, and that the practice of giving the same name to alcohols and their corresponding acids would give rise to confusion in the names of the acid and hydrocarbon radicals which they contain ; the names corresponding to ethyl and acetyl, to benzyl and benzoyl, would become identical if we used the names ethylic alcohol, ethylic acid, benzoic alcohol, benzoic acid. M. Grimaux's proposition was adopted.

The Use of the Prefixes bi- and di-.—M. Bouveault proposed, in the name of M. Hanriot, that the prefix *bi* should be reserved for the denomination of bodies formed by the duplication of organic radicals ; the words dipropargyl, diphenyl, dinaphthyl to be replaced by bipropargyl, biphenyl, binaphthyl.† M. Maquenne preferred to use *di* instead of *bi* for these double radicals ; but it was pointed out that there were only about twelve bodies whose names would need to be changed to be in harmony with M. Hanriot's proposition, whereas the converse proposition would be much more difficult of adoption. M. Grimaux thought that in any case it would be difficult to alter existing nomenclature at once, but proposed that the congress should express a wish that M. Hanriot's system of nomenclature should be adopted for all new bodies, and should gradually replace the existing one. M. Grimaux's modification of M. Hanriot's proposition was adopted.

The Use of the Suffix -ol.—M. Grimaux proposed that the suffix *-ol* should be restricted as far as possible to the alcohols, and that the names of all hydrocarbons should contain the letter *n*. He proposed that the ending *-ene*, employed by English chemists, should be made use of for the aromatic hydrocarbons. *Benzine* and *naphthaline* in French, *benzol* in German, would be replaced by the English term benzene and naphthalene. M. Graebe warmly supported this proposition, and further suggested the abbreviation of naphthalene to *naphthene*. M. Grimaux's proposition was adopted.

Ketones.—M. Friedel pointed out the ambiguity which exists in the French nomenclature of the acetones. Di-methyl acetone might mean either the body $CO(CH_3)_2$ or else $CH_3—CH_2—CO—CH_2—CH_3$ (or its isomer). He proposed to adopt the German notation for these bodies, and in general to replace the word *carbonyl* by the word *cetone* (this form being more adapted to the French language than ketone). Dimethyl cetone is then ordinary acetone. The proposition was adopted.

The Group —C≡N.—M. Bouveault proposed to name this group *carbazil*. M. Calderon and other members of the congress were in favor of this name. It was also proposed to use the word *nitrile* universally. M. Grimaux then pointed out that as we made no distinction of nomenclature between the molecules and the half molecule of chlorine, it would be unnecessary to do so in the case of cyanogen, and he proposed that the group —C≡N be denoted by the name cyanogen. M. Grimaux's proposition was adopted.

The Sulphur Compounds.—M. Chabrié read a report on the sulphur compounds. He complained that a certain number of chemists used the term *sulphine* for compounds containing no oxygen, and which should properly be termed sulphides. He proposed that the name sulphine should be reserved for compounds of the formula $(SO)R_2$, sulphones for compounds $(SO_2)R_2$, derived respectively from sulphurous and sulphuric acids. This nomenclature is used by Beilstein in his invaluable compilation. It is naturally applicable to corresponding selenium and tellurium compounds. It was decided to refer M. Chabrié's report to the permanent committee.

Ring Formulæ Containing Nitrogen.—M. Bouveault read a long report on the subject. He proposed to adopt Widmann's nomenclature, with certain modifications in the details. A protracted discussion ensued, and finally M. Graebe proposed that M. Bouveault's report should be printed and widely distributed, so as to elicit the opinion of all the chemists who had specially devoted themselves to the study of these compounds, and this was agreed to.‡

Naphthalene.—M. Noelting read a report on the nomenclature of the naphthalene derivatives. He began by describing the various notations of Beilstein, Graebe and Noelting, Meldola, Weinberg, and the Swedish chemists. He proposed to denote the carbon atoms of the naphthalene ring by figures and to extend this system to anthracene, phenanthrene, etc. M. Noelting's proposal was adopted after discussion. The figures will be found below in the summary of the resolutions of the congress. It was agreed, on the suggestion of M. Auger, that when it was known that the radicals of a given di-substituted compound were in different rings, but their exact position was uncertain, they should be denoted by the symbol AB.

Benzene.—M. Combes read a report on the numeration of substituted benzene derivatives. He proposed to assign the place (1) to the hydrocarbon radical containing the smallest number of atoms of carbon ; in the absence of a hydrocarbon radical he proposed to begin with the group having the lowest "molecular weight." M. Combes gave as the reason for choosing the simplest hydrocarbon for the position (1) that it was this one which was generally attacked last by oxidizing agents.

M. Alexeieff pointed out that the oxidation of paracymene, $C_6H_4.CH_3.C_3H_7$, by the action of air and caustic soda, gives rise to cuminic acid, $C_6H_4.CO_2H.C_3H_7$, and that in this case the position (1) would be changed, although there was no transposition in the molecule.*

M. Combe's report was referred to the permanent committee.

The general meeting for the discussion of the report of section IV. was held under the presidency of M. Friedel, in the absence of M. Berthelot.

The following resolutions were adopted :

(1) That an international committee, with power to add to its number, be formed whose object shall be to promote uniformity of chemical nomenclature.

The following gentlemen were nominated to serve on the Paris committee : MM. Berthelot, Friedel, Gautier, Grimaux, Jungfleisch, Béhal, Bouveault, Combes, Fauconnier.

That the committee shall immediately request the following gentlemen to join them : MM. Alexeieff (Russia), Armstrong (England), Baeyer (Germany), Beilstein (Russia), Boukowski Bey (Turkey), Calderon (Spain), Cléve (Scandinavia), Franchimont (Holland), Graebe (Switzerland), Istrati (Roumania), Lieben (Austria-Hungary), Noelting (Germany), Paternó (Italy), Ira Remsen (United States).

(2) The two carbon atoms in ethylene and the two hydrogen atoms in urea shall be distinguished by the letters *a* and *b* (proposed by MM. Graebe and Franchimont).

(3) The aldehydes shall be named after their corresponding alcohols (proposed by M. Grimaux).

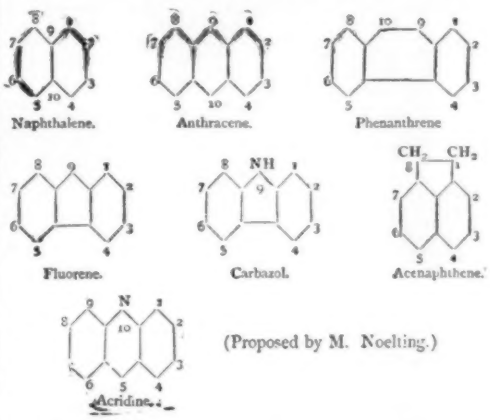
(4) The word carbonyl shall be replaced by the word cetone† (proposed by M. Friedel).

(5) The group —C≡N in organic compounds shall be called cyanogen, instead of nitrile (proposed by M. Grimaux).

(6) The suffix *-ol* shall be reserved as far as possible for alcohols. In the hydrocarbons it is to be replaced by the ending *-ene* (proposed by M. Grimaux).

(7) The prefix *bi-* shall in future be reserved for bodies formed by the union of two radicals such as biphenyl $(C_6H_5)_2$, bipropargyl $(C_3H_3)_2$, and the congress expresses the desire that this nomenclature may be gradually adopted for bodies already known ; the prefix *di-* to be used as at present, to denote bodies formed by double substitution (proposed by M. Hanriot).

(8) The different carbon atoms of naphthalene, anthracene, phenanthrene, fluorene, carbazol, acenaphthene, acridine, shall be numbered as follows :



(Proposed by M. Noelting.)

(9) The proposition to denote the carbon atoms of quinoleine by α, b, γ for the pyridine ring, and *o*, *m*, *p*, *a* (ortho, meta, para, ana) in the benzine ring,‡ which had been voted at the sectional meeting, was adjourned by a vote of 42 against 26, and referred to the permanent committee.

After the carrying of the resolutions, M. Friedel made a short speech, in which he thanked especially the foreign members for their attendance and help. Some people might, he said, think that the section had accomplished but little ; that, however, was not his opinion ; their aim had been to help workers in their work, and nothing could be more conducive to this aim than the use of the same language among the chemists of all countries. He felt sure that their efforts would prove fruitful in the future, and he hoped that by next year the international committee would be able to report such serious progress as to justify the summoning of another congress.

Thus terminated the formal proceedings of the section and congress, which had been marked throughout by the greatest good feeling among the *savants* of the various nations represented. On Sunday the congress was brought to a final close by a banquet offered to the foreign members at the Terminus Hotel.—*Nature*.

* The Comite Consultatif des Stations Agronomiques et des Laboratoires Agricoles has issued a code of the methods of analysis of manures, and these are at present obligatory.

† In France the word function is used in the following sense : Methyl alcohol gives rise by substitution to compounds whose chemical behavior is similar to its own, and are therefore said to have the same chemical *function*. The group $CH_3.OH$ is thus characteristic of the *primary alcohol function* ; similarly, the group C=C of the ethylene function, the group H.C=O of the aldehyde function, etc.

* Or isoallylene.

† It may be mentioned that whereas in England the use of the prefix bi- has been almost entirely abandoned, in France it is still employed, though no rules for its use have hitherto been given ; the terms *di-nitro benzine* and *benzine bi-nitre* denote the same body.

‡ The nomenclature of the pyridine and quinoleine derivatives agreed to by the section was afterward referred back to the committee.

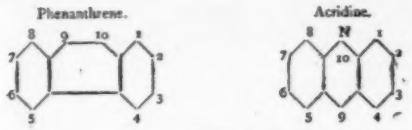
* It may be remarked that this difficulty is inherent to the case, since the oxidation of paracymene by chromic acid gives rise to paratoluic acid.

† This applies only to French nomenclature.

‡ Lellmann's notation.

THE INTERNATIONAL CHEMICAL CONGRESS—A CORRECTION.

A misprint has occurred in the notation adopted by the chemical congress for phenanthrene. The secretary of the nomenclature section has also informed me that a slight modification has been made on the minutes, with regard to acridine, to make the notation adopted correspond more closely to that of the other "multi-ring" compounds. The two formulæ should be—



LANTERN SLIDE MAKING.*

By E. H. JAQUES.

LET us consider the requisites of a good lantern picture. First, of course, comes artistic composition, the arranging of the subject in such a manner that as the eye wanders over it its beauties continue to grow, and the imagination receives an unalloyed feast of satisfaction and pleasure. To some extent I think it possible to teach the art of composition—at all events, so far that its simplest canons may escape violation—but the capacity of rendering true art is a gift of nature. Secondly, the technical excellence of the picture, its mechanical production.

The wet process, properly understood, I believe it is generally admitted, yields the best results in many cases. That it is at times a somewhat troublesome process I frankly admit; still, with care and observation, its difficulties can be overcome. I shall treat of the collodion process only, leaving that of albumen for a future paper. Collodion—that is, pyroxyline dissolved in ether and alcohol—forms the vehicle to receive the sensitive salts, and a collodion that has been iodized some time is necessary, otherwise the high lights of the pictures will suffer. Thin glass cut to the standard size is taken, and after standing some time in sulphuric acid and water, it is carefully dried with a cloth free from soap or other grease. One side of the glass is then coated with the following solution, which must first be filtered through filter paper:

White of egg, well beaten.	
Ammonia liquor 0·880.....	1 ounce.
Water according to quantity of albumen.....	15 to 20 "

The coating is performed by pouring a small pool in the center of the plate, then gently inclining it so that it runs to each corner; the excess may be thrown away. So soon as the plates are dry, they are ready for use. With a soft brush carefully dust the prepared surface, flooding it with collodion in a similar manner, but returning the excess to the stock bottle. This is to avoid dust, a serious enemy. During the draining the corner should be kept in contact with the bottle, and the plate gently rocked to avoid a streakiness or uneven setting of the collodion. Directly it is sufficiently set—the best test of which is trying the upper corner with the finger—it is steadily and evenly lowered into the sensitizing bath by means of a dipper.

A good bath for lantern slides is made as follows:

Pure nitrate of silver recrystallized...	40 grains
Water distilled...	1 ounce

rendered slightly acid with C.P. nitric acid, one or two drops of which will be sufficient for 12 ounces of solution.

When the bath is mixed, for each twelve ounces add half an ounce of the iodized collodion, and shake very thoroughly; let stand a couple of hours, then filter. The bath should now be quite clear and in good working order, but may occasionally be placed in the sun for a few hours, and afterward filtered, when it will work cleanly until the silver is exhausted. When the plate has been in solution about two minutes it should be slightly moved to help the escape of the solvents, and in about four minutes may be examined by yellow light. If the surface is free from greasy lines it is ready for exposure in the camera.

A good negative is necessary for a successful slide. It should be "plucky," so as to admit of a fair exposure.

A good developer is made as follows:

Protosulphate iron.....	½ ounce.
Acetic acid...	2 "
Honey	1 "
Alcohol....	¼ "
Water.....	8 "

Use plenty of developer, and cover the plate in one even wave; never mind spilling a little, though practice will enable you to avoid this. As soon as all detail is well up, thoroughly wash and intensify with—

Pyrogallic acid.....	24 grains.
Citric acid..... ...	24 "
Acetic acid.....	¼ ounce.
Water.....	24 "

Enough to cover the plate is taken, to which, immediately before use, a few drops of the silver bath are added.

Do not over-intensify, as the picture does not lose much in fixing, for which operation hyposulphite of soda may be used on the ground of safety, but cyanide of potassium acts more quickly, and perhaps more cleanly. Slides by this process are a good color, and do not need toning. A coat of clear varnish improves the transparency of the shadows.

Whether printing in contact or by means of the camera, I strongly recommend a full exposure. Gelatine plates are sure to show fog if forced, and however slight that may be, it should insure their immediate rejection. Indeed, it is well to select a really good slide as a standard both as to density, tone, and clearness in the high lights, and those that do not come up to it should not be kept.

For dry plates I prefer a soft negative full of detail. If the skies are not sufficiently opaque, they must be stopped out.

* Abstract of a paper read before the Birmingham Photographic Society.

The solutions required are ten per cent. ones of the following: Pyrogallol, bromide of potassium, ammonia, carbonate of ammonia, and carbonate of potash. The pyro is mixed as follows: Four ounces of sulphite of soda are dissolved in boiling water and rendered acid with citric acid. The pyro is then added, and the whole made up to ten ounces with water. The other chemicals are simply mixed with water, and all will keep well. A developer giving a beautiful purple tone with Mawson's and Thomas' plates is—

Pyro solution..... ...	30 minims.
Bromide	30 "
Ammonia.....	30 "
Carbonate ammonia.....	30 "
Water to make up to.....	1 ounce.

The same color can be obtained with Fry's plates by slightly increasing the exposure and bromide, while a fine engraving black is got by shortening the exposure, increasing the ammonia, and leaving out the carbonate of ammonia. Sepia is obtained by full exposure and using carbonate of potash or soda in place of ammonia; but some makes of plate will not yield the sepia tone.

While the plates are developing, keep them in motion; it adds to their vigor, and prevents flatness, and also deposit settling upon them. After fixing and moderately washing, they may be cleared in—

Alum.....	2 ounces.
Citric acid.....	½ "
Water.....	10 "

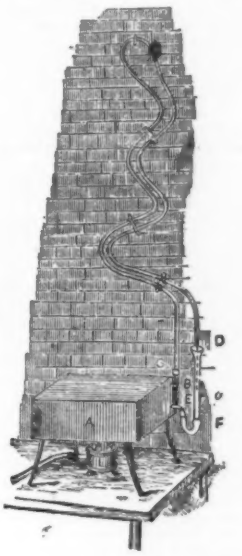
The addition of two ounces of protosulphate of iron and a quarter of an ounce more of citric acid will considerably moderate the tone, and by slightly reducing the slide increases the clearness of the high lights. If any deposit appears upon the surface, rub gently with the finger or a tuft of cotton wool. The slide is now well washed, allowed to dry slowly away from dust, and then varnished.—*Reported in Photo. News.*

A CONSTANT WATER-BATH.

By Dr. BENNETT F. DAVENPORT.

A DESCRIPTION of this apparatus will be found in the *Pharmaceutische Rundschau* for March, 1887, and in the *Proceedings* of the American Pharmaceutical Association for 1887. It has proved so satisfactory that I think it worth while to repeat the description here for the information of chemists. I have kept my bath boiling day and night seven days in the week, and have added water to it but five times in as many years.

It consists of the square box, A, supported over a



Fletcher's solid flame burner. The top of the box, 15 × 15·5 inches, is formed by a brass plate, ⅛ inch thick, which thus is stiff enough to support a considerable weight without yielding, the sides and bottom being sheet copper. From the point, B, projects a ½ inch brass tube, B C, which turns up at a right angle. At E is a stop-cock, which is connected by a thick rubber tube with the glass tube, D F, which is fastened against the adjoining wall. Connected with C by a rubber joint is a ½ inch block tin tube of 20 feet length, which extends up the wall in the manner shown to the highest point, T, and thence returns and ends just over the slightly funnel-shaped top of the glass tube at D. The bath being filled with water to just the level, B *b*, may be kept constant by boiling for many days without appreciable loss of water, the steam being condensed in its passage up or, if uncondensed before it reaches the point, T, in its passage down the block tin tube. In flat-bottomed platinum or porcelain capsules, evaporation goes on very rapidly when placed on top of this water-bath. The whole surface of the bath is nickel plated.—*Journal of Analytical Chemistry.*

[FROM THE AMERICAN GEOLOGIST.]

METEORITES AND WHAT THEY TEACH US.

I.

By H. HENSOLDT, Ph.D., Assistant, Natural History, School of Mines, Columbia College, New York.

THE nebular hypothesis of the great Laplace, which very ingeniously accounts for the origin of what we call heavenly bodies by assuming that the materials now composing them, say the elements, were at one time distributed in a gaseous state through space, throughout vast and theoretically infinite space, that our present worlds are the outcome of an elaborate condensation process which these originally rarefied materials underwent, the accounting for planets or satellites traveling around a central body by assuming that they owe their origin to a ring or a succession of rings thrown off by this central body, from its equatorial region, in consequence of the centrifugal force getting the better of the centripetal—this wonderful nebular hypothesis has been recently and is even now in danger of being superseded by another, not quite so sublime, if I may use this word, though grand enough in some of its aspects, but one which, if it appeals less to our imagination, is more capable of verification by direct observation, and which apparently carries a far greater degree of probability.

This new hypothesis may be termed the dust hypothesis. It assumes that the universe, or a great part of it, is full of minute, dust-like particles of heterogeneous character, floating about in the ether or traveling in definite courses; that if one of these particles happens to come in contact with another, or very near it, there is mutual attraction and adhesion; that the joined particles will travel onward with their attracting force thus increased, drawing other particles to them, one here and one there, and form the nucleus of a body which keeps growing as it travels into new regions of space, exhausting them of the materials within its reach. The more it grows, the more its sphere of attraction increases, the more rapid the accumulation, which is unlimited, till we have a mass a foot in diameter, a planet like our earth, a vast body like the sun, or some still grander one, like that distant giant which compels our sun to travel in its unknown course.

This new hypothesis, which deserves our closest attention, as it throws a new light on the origin and character of our own planet, and which is calculated to revolutionize our present conceptions of geological research, is the outcome of the study of meteorites—those remarkable bodies of extra-terrestrial origin, which are now so eagerly collected and so highly valued, although less than a hundred years ago they were barely noticed or at best regarded merely as curiosities by the learned or as objects of evil portent by the superstitious.

It may seem incredible to those who hear it for the first time that a globe like the earth, with its diameter of eight thousand miles, should be a mere accumulation of particles, gathered around a nucleus of cosmic dust as it traveled on its way through cold and pathless oceans of space. But we have the fact of our earth constantly attracting to its surface substances from the inter-planetary regions, from the most impalpable dust to meteoric masses weighing tons, a process which has been going on year by year, through the geological ages of a duration probably incomprehensible by us. The earth is increasing in weight thousands of tons annually through the fall of meteorites alone, but this is as nothing compared with the aggregate weight of the dust-like particles attracted to its surface during a like period. Prof. Nordenskjold, on his various expeditions to Greenland, as well as on his famous Vega expedition, frequently observed the snow or ice covered with metalliferous dust and other particles which were doubtless of cosmic origin, as they were found in regions far from the habitations of man, and were unlike anything that could have been transported there by atmospheric or other agencies from a terrestrial source, and no matter *where* he examined snow, whether in Greenland, Spitzbergen, or the frozen coast of Siberia, or in his own native Sweden, he never collected less than a milligramme in weight of meteoric particles from a square yard of surface. In one region, for instance, on his Vega expedition, he found the snow covered for miles in extent with minute and very perfect crystals of yellowish color, like crystallized sand grains. They were about 1 mm. in diameter and seemed to belong to the rhombic system, as they had one perfect cleavage and formed striated prisms, terminated at either end by a truncated pyramid.

Now, one milligramme to every square yard of the earth's surface, which is probably far below the *annual* fall of meteoric dust particles, amounts for the whole globe to no less than five hundred million kilogrammes—about half a million tons—too important a factor to be neglected when the fundamental facts of the geological history of our planet are enumerated. That small quantities of cosmic dust, containing iron, nickel, cobalt, carbonaceous substances, and phosphorus, constantly fall, with other atmospheric precipitates, on the earth's surface is a well established fact, and there is even ground for believing that this deposit may play an important part in the economy of nature in supplying phosphorus to soils already exhausted by the growth of crops. Farmers have long been taught by experience that an exhausted field, if left untilled for a number of years, will regain its fertility in proportion to the length of time during which it remained fallow.

The earth, traveling in its orbit around the sun, and onward with the entire solar system around some unknown and still greater center of attraction, is constantly traversing new regions of space, which it depletes of meteoric dust and meteorites, thus steadily—no matter how slowly—increasing in diameter. Now let this growth continue till the earth has just twice the attractive power which it now possesses; we should then have twice the number of meteorites and double the quantity of dust falling annually upon it than now. Fortunately for our heads the earth has not as yet attained very formidable dimensions, but we may look upon it as an established fact that it constantly gains in weight and that in proportion to such gain its attractive power steadily increases. The attracting force of the sun is so enormous that a perpetual hail of meteorites and a torrent of dust particles must rush upon it from all directions, and some of the foremost observers are now of opinion that these falling bodies are the sole cause of the sun's heat. In the light of this theory our earth is a young and growing, not an old and dying planet, a planet with a future, which ought to be cheerful news to all of us, although we shall not live to reap the benefit of it; and the sun, far from being on its last legs as an expiring luminary, is steadily gaining in heat and lighting capacity.

Now, in how far do the facts revealed as yet by the study of meteorites support this hypothesis, and what do meteorites teach us in reference to the character of our own planet? That an accumulation of cosmical particles, no matter how small, is in itself sufficient to account for the origin of planetary masses or fixed stars, no matter how large, nobody can deny after a moment's reflection; it is merely a matter of time for any given

body to attain any given size, and if the accumulation is at first extremely slow it must not be forgotten that it increases enormously with the growth of the mass.

But since the internal structure of meteorites, and especially that of the so-called stone meteorites, has been more carefully studied, *additional* evidence has been furnished which almost amounts to proof that at least many of the meteorites now in our museums and private collections have originated from the accumulation of small particles in the manner above described. Gustav Rose, of Berlin, one of the most careful observers, and whose classification of meteorites is now adopted even by the great Tschermak, the meteorite-investigator *par excellence*—Gustav Rose was the first to draw attention to the fact that the majority of the stone meteorites as yet discovered are composed of little spheres or "chondri," globular masses, varying in diameter from the merest dust to that of a walnut. He proposed the name of *chondrites* for such masses, but they form a class so great in proportion to the rest of the recorded stone meteorites that Tschermak found it necessary to subdivide them into more than half a dozen varieties or species. This chondritic structure differs from anything we find in terrestrial rocks, except, perhaps, in the oolitic limestones, but here due to totally different causes.

These meteorites are composed of little spheres or globes, either perfectly round or slightly oval, sometimes flattened or pressed, as it were, out of shape, and either cemented together by an interstitial paste or matrix, or adhering only loosely, with little or no interstitial matter to bind them. These chondri consist of minerals which are also of common occurrence in terrestial rocks, although never in this peculiar form. They are either composed of olivene, bronzite, augite, triclinic feldspar, or metallic iron, or of two, seldom three, of these combined, never of anything else, except occasionally of glassy matter. The most significant fact is that nearly every chondrum is surrounded by a *distinct crust*, as if it had once been an independent cosmical body—a miniature meteorite; and perhaps equally remarkable is the resemblance, not merely in structure, but in composition, between these chondritic meteorites; and we must bear in mind that of every ten stone meteorites, eight at least are chondritic. This resemblance is perfectly astonishing, and all the more so as we have nothing like it among terrestrial rocks. Every experienced petrographer knows that terrestrial rocks of the same character and composition will present, under the microscope, the most striking structural differences if they are merely gathered from different localities (often less than half a mile distant from each other). No two granites, basalts, dolerites, serpentines, are alike. There are differences even in the same granite from the same locality, and if we prepare twenty sections from one piece not larger than a walnut, the probabilities are that each will show something that cannot be observed in any of the others.

But the chondritic meteorites, no matter when or where they fell, whether in Japan or the desert of Sahara, in Great Britain or Bolivia, practically agree in structure and composition, and the resemblance is often so great that even a Daubree or Tschermak could not, in many instances, tell the section of one from that of another except by its label. Thus, for instance, the meteorites of Dhurmsala and Fayette county are absolutely identical in mineralogical composition as well as structure, the similarity extending even to the smallest microscopical details. The former fell 29 years ago in Punjaub, India, while the latter—the largest and perhaps the finest stone meteorite as yet discovered on the continent of America—was found by the writer near Lagrange, Texas, in January, 1888. Now these localities are more than 6,000 miles distant from each other, and there is also a great difference in the dates of fall (the Fayette county meteorite, from the appearance of its crust, must have fallen more than fifty years ago), yet the microscope reveals absolutely no difference in the sections,—always the same chondri or their fragments, always the same five minerals, olivine, bronzite, augite, plagioclase, and iron, as the principal constituents. This would tend to show that there exists a surprising uniformity among the cosmical particles from which meteorites originate.

Fortunately the labors of Tschermak and Daubree have made it possible for us to distinguish without much trouble an olivine chondrum from one of augite, bronzite, or triclinic feldspar, but as we cannot here go into elaborate details, we merely point out in a general way that chondri which are traversed by parallel bars, or a sort of grating, may be put down as olivine, those with a granular structure as augite, those exhibiting a fine parallel striation between crossed Nicols as triclinic feldspar, and those which show a peculiar fibrous, radiating, or fan-like structure, as bronzite. The feldspar is almost invariably anorthite, the most basic of all feldspars—a significant fact, as we shall see later on; but we occasionally meet with a peculiar *singly refractive* variety of plagioclase, which has been called maskelynite, but which in the opinion of the writer is nothing but anorthite rendered singly refractive by partial fusion. The astonishing similarity between chondritic meteorites enables us to limit our description to a few prominent types. The meteorite of Ranazzo, which fell in Italy in 1824, consists of chondri cemented together by a dark paste of carbonaceous matter, in which an immense number of particles of pure iron are distributed. These of course cannot be distinguished under the microscope from the black matrix, as both are perfectly opaque. But an ordinary hand lens reveals the remarkable fact that each chondrum is surrounded by a *crust of metallic iron*. Sometimes this crust is very thick, so that it often seems as if a chondrum of iron had a nucleus of olivine. The Tieschitz meteorite which fell in Moravia in 1878 is composed, in part, of very perfect chondri, but the section also reveals a number of angular fragments. Bronzite chondri, recognizable by their peculiar fanlike or fibrous structures, are beautifully developed. Many will remember that about ten years ago Dr. O. Hahn, of Rutlingen, a lawyer by profession, rushed into print and insisted upon making himself ridiculous by the publication of a bulky work with 33 photographic plates on organic remains in meteorites, which he pretended to have discovered. This worthy man, who had little petrographical knowledge, was entirely misled by the fibrous structure of these bronzite chondri, which is often very curious, reminding one of fossil corals, and he took great pains in describing no less than twenty-eight species of corals alone, besides many sponges, crinoids, and what not in the organic line, which he had discovered in meteoric sections, but which nobody else could see in them. He was guided by accidental resemblances; the things he observed were such as one might see in the clouds, and any one gifted with a little imagination will, if he looks long enough, discover corals, foraminifera, fossil fishes, and even dromedaries in almost every section prepared from a chondritic meteorite.

The Monroe meteorite, which fell in Carbaras county, North Carolina, in 1849, does not at first sight appear very chondritic, but if we carefully examine a thin section we find it to be almost entirely composed of chondri closely packed or welded together and somewhat pressed out of shape. Sill more difficult is it to recognize the chondri in the meteorite of Aumale, Algeria, yet it is a chondite, and we can still distinguish the parallel bars of the olivine, the coarse granulation of the augite, the striation of the feldspar, and the radiating fibers of the bronzite.

Chondritic structure, as already shown, is peculiar to meteorites. We have nothing analogous in terrestrial rocks except in the oolitic limestones, but here due to entirely different causes. In the Portland oolite from England, for instance, we have spherical deposits of carbonate of lime which have formed in concentric crusts around nuclei. These nuclei consist of sand grains, and sand grains also form the interstitial substance between the little globes. Such a section presents a strikingly beautiful appearance in polarized light, as the lively chromatic display of the quartz nuclei contrasts with the layers of carbonate of lime, which are indifferent to polarization. We also find occasionally in terrestrial rocks, and especially in eruptive ones, a tendency on the part of certain crystals to gather around some nucleus and form spherical aggregations, viz., during the process of solidification or cooling of a molten mass, crystals will sometimes arrange themselves very symmetrically around some nucleus, as in certain augite lavas of Tahiti. Again in the sections of Cornish granites, especially of the famous luxulyanite, which is found in bowlders in the vale of Luxulyan, Cornwall, we have needle-shaped crystals of tourmaline radiating starlike from a common center—a marvelous object for the polariscope; but all these phenomena are essentially different from those presented by the chondri of meteorites.

But if from such data as these, viz., from the fact that the great majority of the known stone meteorites are chondritic, meteorite investigators who are petrographers, and astronomers who are *not* petrographers, jump to the conclusion that *all* meteorites have resulted from the accumulation of cosmic particles, they are, in our humble opinion, greatly mistaken.

That the true chondrites have originated in this manner is extremely probable, and if our individual opinion is worth anything, the writer may add that he is perfectly convinced of it. But then we have quite a number of stone meteorites which are not only *not* chondritic, but which are so constituted as to preclude the possibility of their ever having *been* chondritic, and which for a number of other reasons cannot have resulted from an accumulation of cosmical particles. Some of these meteorites have a *brecciated* structure, almost identical with that of some of our volcanic ash rocks and tuffs. They consist of little angular fragments, mixed with larger ones, broken crystals of various silicates and other detritus, exactly as we find it in volcanic ash rocks.

Of this class the meteorite of Petersburg, which fell in Lincoln county, Tenn., in 1855, is an example. In a section prepared from this meteorite we see nothing but sharp fragments and grains of pyroxene, plagioclase, and a variety of other minerals difficult to determine; a number of rusty spots are due to limonite, which has resulted from the decomposition of some of the iron particles.

Very similar, only a little coarser in structure, is the Frankfort meteorite, which fell in Franklin county, Alabama, in 1868. A glance at the sections of these meteorites suffices to convince us that they represent a totally different type, that they have nothing in common with the chondrites before described, and it so happens that they agree in almost every particular with certain of our ash rocks and tuffs. In the writer's opinion they cannot have originated in any manner differing fundamentally from that which led to the formation of our compressed terrestrial ash rocks. In sections prepared from certain volcanic ash beds in Central America, Arizona, and California, we have essentially the same structure and very nearly the same mineralogical composition, the same angular fragments, the same detritus, the same color even; and we might go on multiplying such examples of almost absolute coincidence.

Another meteorite which will not fit in the accumulation hypothesis, and which greatly bothers the dust people, is the famous meteorite of Rittersgrun, one of the most remarkable and beautiful meteorites, which fell in Saxony in the year 1164. It is composed of metallic iron and crystals of a beautiful yellowish green color, which at first were believed to be olivine, but which are now known to be bronzite. Then we have meteorites of a basaltic structure, like that of Juvinas, which fell in France in 1821. It is chiefly composed of rods of triclinic feldspar (anorthite) and augite. Such crystals could only have originated during the very slow cooling of a molten mass under extreme pressure. Now the structure of the famous Ovifak basalt is so similar to that of the Juvinas meteorite that it is almost impossible to distinguish, under the microscope, the sections of the former from that of the latter. The Ovifak rock is composed of the same minerals in the same proportion and in precisely the same development, viz., rods of anorthite, granules of augite, and native iron. Native iron! Where did that come from? What business has metallic iron in a terrestrial rock? Well, the basalt of Ovifak *is* the most remarkable terrestrial rock with which we are acquainted. Its discovery has been a great shock to the army of meteorite collectors all over the world, a shock from which they have not even yet quite recovered, for now the presence of metallic iron can no longer be relied on as a test feature of a meteorite.

Previous to Nordenskjold's great discovery, non-artificial metallic iron had never been known to occur on this terrestrial globe, whether as a constituent of rocks or in the shape of veins, lodes, crystals, or loose masses. It was invariably found oxidized or combined with carbon, silica, sulphur, and other substances from which it had to be first separated by more or less complicated processes.

But metallic iron was met with in the meteorites which have from time to time fallen upon the surface of our planet. These mysterious visitors from other spheres not only often *contain* iron, but they are in the majority of cases almost entirely composed of it, and it is more than probable that the first iron with which man became acquainted, and which he used for tools and implements, was the iron of meteorites.

When Cortez had completed the conquest of Mexico, the Spaniards, among a great many other peculiar and extraordinary observations which they made in that remarkable country, were particularly struck and puzzled by one fact. They noticed that the Aztecs possessed certain implements, such as knives, daggers, etc., made of iron, but it seemed that only the most distinguished of the natives possessed such, that iron was a great rarity, and was prized higher than gold. At first the Spaniards believed that the Aztecs extracted the metal in some crude fashion from its ore, which abounded in many parts of the country, but they soon ascertained that this was not the case. They found that not a single smelting furnace existed in the empire, and their surprise was not small when they learned that the Aztecs were totally unacquainted with any method of extracting the iron from the ore, which indeed they had never suspected of any kinship with the highly valued metal.

The question whence the Aztecs had procured the little iron they possessed became a perplexing problem to the Spaniards, a problem which they were never able to solve. The natives do not seem to have enlightened them much on the subject, for when asked they mysteriously pointed to the sky and indicated that they obtained their iron from the regions above. Such assertions no doubt the Spaniards received with an incredulous smile, and they concluded that the Aztecs procured it by way of traffic from some other perhaps more civilized nation, which they suspected to exist and kept looking for, north and south, for more than a hundred years. It was left to modern science to unravel the mystery. The Aztecs were quite correct. The iron of which they had made their implements was not fashioned from materials of this terrestrial globe, but had come to them from the unknown regions of space. Their iron was in fact of meteoric origin, like that of the Mayas of Yucatan and the Incas of Peru, of which many weapons are still preserved in collections.

(To be continued.)

THE GERM ARMY—HOW IT MAY BE ROUTED.*

By A. ARNOLD CLARK, Lansing, Mich.

IT is a favorite notion of modern physiologists that the human body is a sort of body politic—a commonwealth inhabited by an immense multitude of living cells. It is almost impossible not to think of these cells as reasoning beings, as we find each struggling for its own existence, but dependent on its neighbors and working with them in the common object of building up the tissues of the body—turning food into muscle and nerve.

In the midst of this "busy whirl of industry," these cells are constantly changing, giving birth to new cells, dying, and the human body, like the great world we inhabit, is the constant theater of birth and death.

These invisible cells have their invisible enemies; these enemies are popularly called germs. When these germs of disease gain an entrance to this citadel—the human body—through the air we breathe or the water we drink, they commence what Virchow calls a "struggle" with these cells, and we very properly speak of an "attack" of disease.

Vivid pictures have been drawn of this battle, how sometimes the germ is destroyed by the cell, how sometimes it conquers the cell, bursts it open, and rushes to destroy other cells.

Perhaps it might be more accurate to speak of the germs breaking up the body compounds into poisons, each germ producing its own peculiar poison, its own peculiar symptoms, so that a sick man is like a city that has been sacked, plundered, and debauched by a foreign soldiery, all the healthy avenues of circulation blockaded and clogged.

Without entering into an intricate explanation of how these germs produce disease in the human body, it is enough to say that where the vital forces of the human body are stronger than the germs, we have what is called a light attack. At times we have for a while a drawn battle, then the citadel is rebuilt from its ashes. When on the other hand these little soldiers of the great destroyer win a complete victory, the citadel is taken, the body dies, and we realize the truth of Victor Hugo's words: "It is with the infinitely little that the infinitely great conquers us."

NON-PATHOGENIC GERMS.

Not all of these "infinitely little" germs are the enemy of man. We have to thank them for our daily bread, our vinegar, and our beer. In the accompanying diagram you will notice a picture of the yeast plant. This is the great brewer which turns our barley into beer and our grape juice into wine. As it is impossible to tell at a distance whether an army is friendly or hostile, without a field glass, so it is necessary to magnify all of these pictures. When I tell you that the germs in these diagrams are magnified many thousand times, you will see how "enormously small" they are.

The ancients, unable to understand the wonderful process of fermentation, knowing quite well that it could be no mere chemical process, spoke quite reasonably of the "spirit of wine." "O thou invisible spirit of wine! if there is no other name by which I may call thee, then I will call thee"—saccharomyces vini. When you ladies can your fruit, you know that by boiling it and keeping out the air, it will not ferment. You have kept out the germs of fermentation floating in the air.

In the same way that this yeast plant turns our grape juice into wine, this bacterium termo (see first figure in the plate) turns sweet meat into carrion, and these comma-shaped germs here (near bottom of plate) make a well man sick with Asiatic cholera.

* A paper read at the Hastings Sanitary Convention, December, 1888.

RAPID MULTIPLICATION OF GERMS.

But how, you ask, can so few germs as may find an entrance into your fruit on one exposure to the air produce this dreadful havoc of fermentation? How can so few germs as are sometimes carried in a letter cause such dreadful outbreaks of disease? The answer lies in the rapid multiplication of these germs.

There are two ways in which germs reproduce. Usually one germ lengthens out and divides, producing two. Sometimes a bright oval spore or seed is formed in the germ, the germ is broken and the new germ is formed. This spore is the egg of a new germ. Think of an organism not so large as the point of a pin laying an egg!

In the rapid multiplication of these germs there is a good chance for a play of the imagination. Cohn saw the bacillus subtilis divide every twenty minutes. Assuming that each germ divides into two only once each hour, then in two hours 4 will be formed; in three hours, 8; in four hours, 16; in five hours, 32; in six hours, 64; or, at the close of twenty-four hours, at this rate, there would be 17,000,000 descendants of one germ. Or in five days at this rate, the descendants of a single germ would, says Cohn, fill all the oceans of the earth, and yet they are so small that if drawn up in battle array millions of them may be crowded into a cubic inch. And, though they are so light that Tyndall saw them dancing in the sunbeam, yet Cohn estimates that in five days the descendants of one germ would weigh 15,000,000 pounds. Of course, germs do not multiply this fast, because they lack the food and for other reasons, but it is only when we understand their power of rapid reproduction that we can understand those great epidemics which sometimes take great cities by storm and even depopulate nations.

It is this rapid multiplication which proves these germs to be living matter. You can dilute strychnine and make it harmless—it don't reproduce. You can't dilute the yeast plant, because it does reproduce. "A little leaven leavens the whole lump." I haven't time to mention the many experiments by which it has been proved that these germs do not develop spontaneously, that each reproduces after its own kind. When you can keep the germs of fermentation out of your fruit, they do not develop spontaneously in the can, and the fruit does not ferment. So the germs of scarlet fever no more arise in the air out of nothing than birds do. It was formerly thought that animals developed spontaneously. Von Helmont gave a formula for the spontaneous production of mice: "Take a dirty shirt, put into it some grains of wheat, subject the whole to heat, and at the end of a certain time there will be a transmutation of the wheat into mice." People used to think that the ooze of the Nile turned into eels. So when contagious diseases were first studied, it was claimed that they developed *de novo*. Scarlet fever and diphtheria were attributed to dirty surroundings, and, when this wouldn't work, to the "will of God."

All this is a thing of the past. A field full of thistles is an indication that the seeds of thistles have been wafted there, and, as you can't gather figs from thistles, you can't get diphtheria from anything but diphtheria. There was no scarlet fever in this country until the germs of scarlet fever were brought to this country one hundred and fifty years ago from a previous case, and if the germs of scarlet fever were all destroyed to-night, scarlet fever would be again a disease unknown. Diphtheria no more arises from the smell of decaying vegetables than bees are generated by the smell of decaying meat, as Virgil believed. Bad-smelling marshes give no more birth to typhoid fever than to snakes and frogs, as the ancients thought. You can no more spontaneously generate a case of glanders than you can the horse that has it.

Koch has given a series of rules which must be followed before it can be said that any given germ has caused a given disease. The germ must be found in the blood or diseased tissues of the person sick; it must be isolated and cultivated and injected in some animal producing the symptoms of the disease, and it must again be found in the diseased tissues of the animal.

This has been done in some diseases, and the germs thus studied are pictured in the accompanying diagram. Before referring to them in detail, I should say that there is almost an infinite variety of germs.

Without attempting any scientific classification, I may say briefly that there are three forms most usually met with: (1) those round like a ball (called micrococci), (2) those long like a lead pencil (called bacilli), and (3) those shaped like a corkscrew (called spirilla). In the process of division, they form chains and swarms. They shape themselves into columns, platoons, phalanxes, squares, and go through as many evolutions as our best trained military troops. They form colonies which are visible to the naked eye, though the individual germs are not. You can see an army at a distance where you cannot see a soldier.

The largest of these germs is the *spirillum volutans*, which is one three-hundredth of an inch long—quite a giant.

Many of these bacilli and spirilla have flagella or cilia by which they move about. You will notice these threads in the bacterium termo and spirillum volutans in the accompanying diagram. They are as much smaller than the germ as the lion's tail is smaller than the lion.

Cohn, describing movable bacteria, said that swarming in a drop of water they looked like an ant hill. Swimming forward, they stop, and without turning around dart suddenly backward, thus forward and back as if executing the movements of a quadrille. Remaining motionless a long time, they dart suddenly forward like an arrow, spin around like a top, and swim like a fish. It is almost impossible not to think of them as possessed of consciousness and having a good time. Dr. Kedzie describing a drop of water full of bacteria said that it looked like an "animated skating rink."

A few weeks ago the SCIENTIFIC AMERICAN printed pictures of seventy-one different varieties of bacteria found in a glass of beer. About eighteen different species exist normally on the teeth. You will notice some of the bacteria usually found in the saliva in one of the figures in the accompanying diagram. Man's mouth is a regular botanical garden.

Experiments made with the books in the circulating libraries of Dresden show that where the leaves of the book are turned with the dry finger, not many germs are found on microscopical examination, but where the finger is wet many germs are found. All of these happened to be non-pathogenic germs, but if a child sick with scarlet fever had been reading that book, the disease might have been spread in that way.

Experiments show that the coins and paper currency of Germany are covered with bacteria. In more senses than one it is "filthy lucre." Perhaps your child is carrying in its mouth the penny that has been paid out by a diphtheritic patient.

The germs of consumption have been found in the dried fly specks on the walls of rooms inhabited by consumptive patients—the flies had eaten the sputa. It is also claimed that the germs of typhoid fever have been carried in this way.

These germs find an entrance to the body through the water we drink and the air we breathe. They abound in crowded rooms. It is these germs, as Tyndall showed, which enable us to see the sunbeam dancing in a darkened room. When people go into a crowded room and breathe through the open mouth, these germs find a ready entrance to the lungs. When you breathe through the nose the germs may be stopped by the moist nasal passages. Probably a good many people might avoid catching some contagious disease by keeping their mouths shut.

The higher up you go, the less number of germs. Some one has facetiously suggested balloons as a health resort. Between one and two hundred miles out at sea very few germs are to be found, and sea breezes coming over this distance are comparatively free from germs.

Experiments show them to be more abundant in the cities of London and Paris than in the suburbs, and more abundant in the suburbs than in the country.

I have thus spoken of germs in general because those germs which are hostile to us come to us in the same manner and under the same guise as our friends. From town to town they go like a conquering army, but unseen. They are the uninvited guests at our banquets, they sparkle in the water we drink, greet us in the letters of our absent friends, and from the person of the pauper infect the millionaire.

We can see the different military tactics of these different germs when we reflect how these germs of erysipelas (referring to diagram) attack only the surface, the germs of cholera the intestines, the germs of scarlet fever come from the flesh dry, those of diphtheria must be dried before they attack us, while those of typhoid fever enter the body wet, just as they come from the infected body.

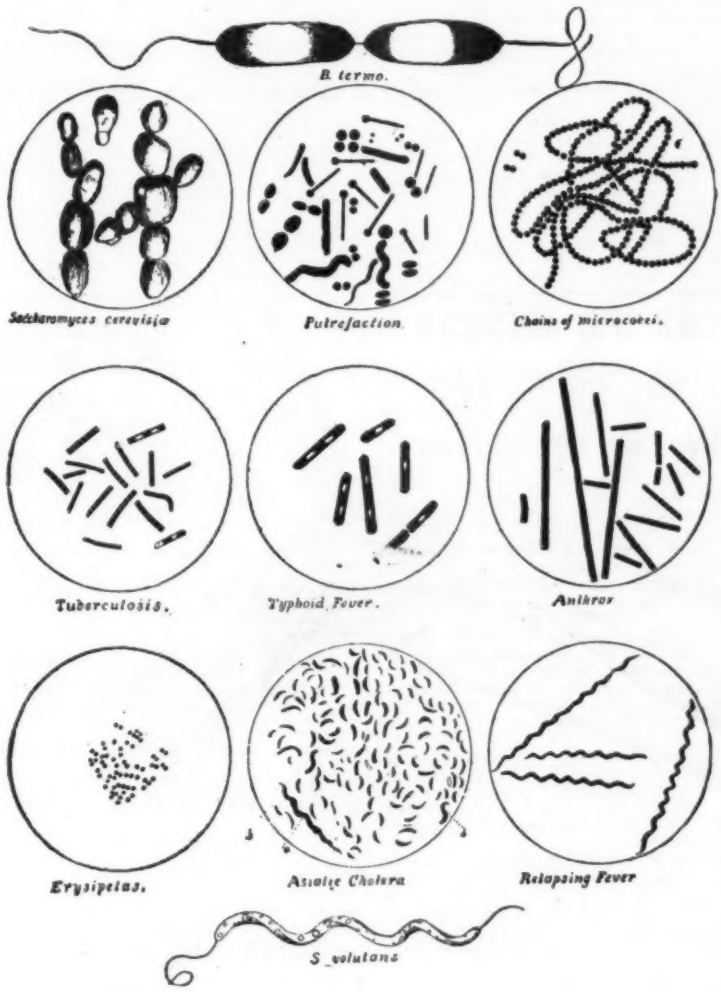
Without referring at length to the action of the different germs pictured in the diagram, I may illustrate by telling a story. A year ago a man sick with typhoid fever went from a railroad construction camp to the city of Irom Mountain, Mich. In a few days he died. The dejections of this patient were not disinfected, as they should have been, and the germs found their way into the water supply of Iron Mountain, and there were three hundred and fifty cases of typhoid fever and thirty-five deaths. The water supply of Iron Mountain literally swarmed with this foreign army of typhoid germs. A jug of the water used by some of the families sick with the fever was sent to Prof. Vaughan of the university. He inoculated a sterilized meat preparation with this water, and this injected in dogs produced a regular run of typhoid fever the same as in man, the germs of the disease being found in the intestines after death. The existence of this germ was also proved by microscopical examination and by the potato culture. Here are thirty-five deaths because of neglect to properly kill the germs which came from the first case. Many other outbreaks might be cited where hundreds of cases have resulted from one.

Not all diseases have been as thoroughly studied as typhoid, and yet we know that they are caused by a specific germ which reproduces after its own kind. In this connection let me tell you another story: Two or three years ago a Pullman car conductor came in contact with the germs of small-pox in his car near Chicago, passed through on the Grand Trunk to Montreal, and was taken sick with the disease. No pains were taken to kill the germs, the ignorant inhabitants refused to vaccinate, declaring it a "wicked attempt to thwart the will of the Almighty," and in a few months over three thousand people in Montreal died of small-pox as a result of the one case.

It was carried to different parts of the United States. Michigan, the most exposed of any State, escaped because Michigan had at her great ports inspectors of travel who vaccinated all who came through and disinfected all clothing, thus killing the germs.

Every week reports are received at the office of the State Board of Health, where outbreaks of diphtheria and scarlet fever have been traced, beyond a doubt, to the germs from a previous case, from letters or clothing. In 1874 there was a case of scarlet fever in a house near Laingsburg. The curtains that hung in the room, the doll with which the child played, and some other articles were packed away in the garret. Five or six years later another family moved into the house and cleaned out the garret. Part of the stuff was burned, but the girl took the doll with which the sick child played, and the two boys took the pictures. In ten days the three children were sick with scarlet fever.

These little invisible enemies of man understand military maneuvers of which the Napoleons of the world never dreamed. They find a hiding place in our garrets and our wells, lurk in the rubbish of our cellars, linger in our hair and clothing, cling to our beds, our carpets and our walls, are brought to us long distances by letters from our friends—more ingenious than the famous Greek horse, they steal in with the family cat and come with the flies. They congregate in poorly ventilated churches, greet us in the kisses of our friends and from the coffin of the mother attack the cradle of the babe.



In the above plate are exhibited eleven specimens of micro-organisms, which are magnified approximately as follows:

	Diameters.
Bacterium termo,* about	2,000
Saccharomyces cerevisiæ (yeast), about	500
Putrefaction (bacteria),† about	1,200
Chains of micrococci,‡ about	1,400
Tuberculosis (bacillus), about	1,100
Typhoid fever (bacillus),† about	1,100
Anthrax (bacillus),† about	1,400
Erysipelas (micrococci),† about	1,300
Asiatic cholera,† about	800
Relapsing fever (spirillum),† about	1,300
Spirillum volutans,* about	500

* "Bacteria," by Dr. Antoine Magnin and George M. Sternberg, M.D., F.R.S., p. 40.

† "Microscopical Technology," Dr. Carl Friedlaender. Frontispiece.

‡ "The Practitioner" (London), vol. xxxii., p. 261.

HOW TO DESTROY THE GERMS.

At last science has begun to see that there is a nobler course than to wait for an attack of these germs and hope that they may be repulsed. The medical profession has sent along its picket line of health officers into the enemy's camp.

All honor to those who stay behind to care for the wounded, but aggressive action must take the place of defensive action, prevention must take the place of cure. When we have found a germ, we must find its germicide. We must kill these germs before they attack us. It is easier. You have probably heard of the Irishman who swallowed a potato bug and then swallowed Paris green to kill it. That is like trying to blow up a foreign army after it has entered our gates.

What shall we do to be saved from these germs? There are many interesting questions in this connection which I have not time to discuss. For example, it has been thought by some that these germs can be made to destroy each other.

It is known that there are some germs that are not dangerous to man which eat up germs that are dangerous. The germs of typhoid fever grow faster in water in which there are no other bacteria.

Koch found that the cholera bacillus would not thrive in beer—it was destroyed by the other germs. Now some have fancied that every hostile germ has its enemy which is innocent to man, and that sanitarians may yet make use of these friendly germs.

VACCINATION.

Neither have I time to speak of the great hopes for vaccination in the future. The principle of military strategy here involved is not to attack the germ, but to strengthen our own fortifications against attack. It is well known that one attack of a disease usually fortifies our body against future attack.

Whether the first army forages and devours the food necessary for the support of that kind of germ (Pasteur), or leaves behind some chemical products in which none of their kind can live (Klein and Klebs), or whether, as some claim, the cells have been educated by the first attack so that they better understand the military tactics of this hostile tribe, and thus acquire vital resisting power (Sternberg), it is enough to know that a conflict with the weak members of one of these malignant tribes fortifies our bodies just the same as a conflict with the most malignant.

Now we can weaken these germs, introduce them into our bodies, they are easily conquered by the cells, and we are vaccinated. The germs don't lose their nature at all. As some one has said, the rattlesnake has not been changed into a frog—we have simply extracted some of its poison fangs.

Against those diseases which cause the most deaths in Michigan there is a practical remedy in the hands of every man. I told you how that dread disease, typhoid fever, which kills a thousand citizens of Michigan each year—mostly those in the prime of life—is spread by the germs in the water we drink. Now what will destroy these germs? Freezing the water will not do it, but boiling the water will do it.

Robert Elsmere preached a good religion when he preached the necessity of boiling all drinking water. Nothing so easy, nothing so potent.

Filtering the water will not destroy these germs. It only takes them prisoners, and when the prison is overcrowded, the filter itself becomes a distributer of germs. Boiling water one-half hour will destroy them. In view of this fact, some one has declared every death from typhoid fever to be suicide or homicide, and if there is any one thing I would emphasize to-night, and have remembered when I have done, it is this simple precaution:

Boil the water; boil it when typhoid fever is prevalent; boil it at the time of year when typhoid is expected; boil it if you have any suspicions about your well; boil it any way. You will hear many precepts at this convention, some, perhaps, which you will forget, but I shall be satisfied if the enthusiasm of this convention reaches the boiling point.

The germs of these other diseases, diphtheria and scarlet fever, enter the lungs through the air we breathe. What will destroy these germs? You may have heard of many disinfectants, but experience in this State has proved that the fumes of burning sulphur will destroy these germs.

You will find it demonstrated in the reports of the Michigan State Board of Health that during the last two years hundreds of lives have been saved by isolating those sick with diphtheria and scarlet fever, and then, after death or recovery, burning sulphur to destroy the army of germs hiding in the house.

Sulphur has long been a good orthodox disinfectant for the next world; we now know that it destroys the little devils in this.

It was an old idea that disease was caused by the possession of devils, and that the way to cure disease was to cast these evil spirits out. Our forefathers used to prick the affected part in the hopes of thus letting the evil spirit out, in much the same way that the Indian medicine men now gather about a patient, one playing the tom-tom to scare the devil out, another jumping on the patient's stomach to stamp the devil out. If the devil doesn't kill the patient the doctor usually does.

Now disease is caused by the possession of evil spirits—devils; but, strange as it may sound, devils that can't live where sulphur is burning.

Such is the foe with which we have to deal. This army of disease germs is the "enemy at our gates." We spend thousands of dollars to maintain a large standing army to protect us against those foreign foes with whom we ought to be at peace. We pay our health officers about enough to keep them in sulphur and boiled water.

But of our Michigan boys who enlisted in the Union army during the late war, disease carried off four times as many as the fields of battle and the wounds of battle. In the Crimean war 20,000 French soldiers died in battle, 75,000 died of disease.

Those great plagues of the middle ages, which swept over Europe like the barbarous Huns and Tartars, caused more deaths in a single year than all the wars of the century.

Like the human race, disease seems to have its home in the East and take its empire westward. Like an invading army, small-pox came to Germany in 1493; to America in 1527. The cholera germs first came here in 1832, and then died out—something like the French soldiers who were unable to endure the climate of Algiers. In India these germs do not die, and every year we fear an invasion. If all the forces of civilization could be gathered here, if once we could kill all the cholera germs in Calcutta, why should not the future Crecy classify this among the fifteen decisive battles of history?

Too often we turn over our mortality statistics and read in the newspapers of so many deaths, such a place, with no other emotion than we experience while reading the market price of our products. But if, as Byron said, it is a

"Dreadful thing to see the human soul take wing—
In any form—or any way."

it is sad to know that over one fourth of all the deaths which occur in this State are from diseases which we know enough to prevent, but do not. Not long ago in one of your neighboring towns there were six deaths from diphtheria in one family in one week, every one of which might have been prevented had every officer done his duty.

On the cars to this convention, whose object is to save human life, I thought of Dickens' beautiful description of the engine which carried away Mr. Dombey after the death of little Paul, and how to him that great iron monster, "defiant of all paths and dragging behind it human beings of all ages and classes, seemed like the type of the triumphant monster Death."

"Away with a shriek and a roar and a rattle—'mid objects close at hand and almost in the grasp—yet ever flying from the traveler," "with a shrill yell of exultation pausing for a minute where a crowd of faces are that in a minute more are not," "away with a shriek and a roar and a rattle, leaving no trace behind but dust and vapor—like as in the track of the remorseless monster Death!" "Away and still away—onward and onward ever, glimpses of cottage homes, mansions, and rich estates that look deserted now as they are left behind, and what else are there but such glimpses in the track of the indomitable monster Death!"

The duty of the state to prevent disease and death! Think of those who, in the prime of life, are ground beneath the iron wheel of this "remorseless monster"! Think of the young, the innocent, who are made wrecks for life! Think of a Proctor in the full brightness of his intellectual manhood cut down by a disease which should be one of the accidents of civilization—and then say, if you will, that the saving of human life is not the first and highest duty of the state.

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TABLE OF CONTENTS.

PAGE

I. BIOGRAPHY.—William H. Cilley.—The death of the general manager of the Oroya Railroad, Peru, for 27 years prominently connected with the railroad interests of the South American republic, his work under Meiggs, and the funeral ceremonies at Lima on the 12th of September last..... 11536

II. CHEMISTRY.—A Constant Water Bath.—By Dr. BENNETT F. DAVENPORT.—An exceedingly simple and valuable improvement for use in the laboratory, by which a water bath may be supplied with water for many days without the use of any external supply. 1 illustration..... 11571

The International Chemical Congress.—An abstract of the proceedings of this exceedingly important congress held in Paris under the presidency of M. Berthelot, composed of some three hundred members..... 11570

III. CIVIL ENGINEERING.—The Channel Bridge.—Preliminary Designs by Messrs. Schneider & Co.—Continuation of this valuable paper, with illustrations of the different types of girder which may be employed, table of the work to be performed in the construction of piers, and other details.—7 illustrations..... 11564

IV. COSMOLOGY.—Meteorites and What They Teach Us.—A very interesting and graphic review of the question of meteorites, their origin, constitution, and effect upon the earth and planetary system.—First installment of an exhaustive and valuable paper..... 11571

V. ELECTRICITY.—The Renard Electric Table Lamp.—A very ingenious attempt at utilizing a primary battery for the self-contained table lamp, giving 25 C. P. illumination, with a weight of 35 pounds, and lasting from 5 to 8 hours.—2 illustrations..... 11551

Electric Lighting.—Report of M. FONTAINE..... 11550

The Electric Lighting of London.—4 illustrations..... 11559

Telephone Protector.—1 illustration..... 11560

VI. HYGIENE.—The Germ Army—How it may be Routed.—By A. ARNOLD CLARK.—A valuable contribution to bacteriology, containing illustrations of different germs provocative of fermentation, putrefaction, and disease, with practical suggestions as to how to cope with them in their ravages among the human race.—11 illustrations..... 11572

VII. MECHANICAL ENGINEERING.—Street Railway Motors Other than Animal, Cable, and Electric.—By HENRY H. WINDSOR.—Steam, air, and chemical motors for use on street railways reviewed.—A report read at the October meeting at Minneapolis of the American Street Railway Association..... 11565

VIII. MISCELLANEOUS.—Lion Hunting in Birmingham.—The escape of a lion and lioness from the Wombwell menagerie, with illustrations of the incidents of the trace and capture of the animals.—8 illustrations..... 11568

IX. GEOGRAPHY.—A Visit to Huelva and the Tharsis Copper Mines.—A review of the surroundings of the Spanish copper mines, incidents of the voyage thereto, and general features of the region..... 11567

Life in Denmark.—A most picturesque and popular account of the life of the peasantry in Denmark, their wedding festivities, their recreations and amusements, and other features of their simple life..... 11567

The Recent Landslip at Quebec.—An account of the recent accident at Quebec, with illustrations of the locality of the landslip and of Dufferin Terrace before the accident occurred.—2 illustrations..... 11568

X. PHOTOGRAPHY.—Lantern Slide Making.—By E. H. JAQUES.—A thoroughly practical paper, with formulæ upon the subject of making wet plate lantern slides..... 11571

XI. PHYSICS.—The Molecular Structure of Matter.—A British Association address by Mr. WILLIAM ANDERSON, member of Institute Civil Engineering, reviewing the entire field of molecular force, the first installment of a very important contribution to advance physical science..... 11562

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